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INTERIM REPORT
February 25, 1993

FOR

BIOVENTING FIELD INITIATIVE

AT

HANSCOM AIR FORCE BASE, MASSACHUSETTS

to

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BIOVENTING FIELD INITIATIVE

HANSCOM AIR FORCE BASE, MASSACHUSETTS

1.0 INTRODUCTION

This report describes the activities conducted at Hanscom Air Force Base (AFB), Massachusetts, as part of the Bioventing Field Initiative for the U.S. Air Force Center for Environmental Excellence (AFCEE) and the Environmental Quality Directorate of the Air Force Armstrong Laboratory. This report summarizes the results from the first phase of the study at Hanscom AFB. First-phase activities include a soil gas survey, air permeability test, in situ respiration tests, and installation of bioventing systems. The specific objectives of this Bioventing Field Initiative are described in the following section. Each site at the base is discussed individually, followed by a description of site activities at the background area.

1.1 Objectives

The purpose of this Bioventing Field Initiative is to measure the soil gas permeability and microbial activity at a contaminated site in order to evaluate the potential application of bioventing technology to remediate the site. The specific test objectives are stated below.

- A small-scale soil gas survey will be conducted to identify an appropriate location for installation of the bioventing system. Soil gas from the candidate site should exhibit high total petroleum hydrocarbon (TPH) concentrations, relatively low oxygen concentrations, and relatively high carbon dioxide concentrations. An uncontaminated background location also will be identified.

- The soil gas permeability of the soil and the air vent (well) radius of influence will be determined. To measure these parameters, air will be withdrawn or injected for approximately 8 hours at vent wells located in contaminated soils. Pressure changes will be monitored in an array of monitoring points.

- Immediately following the soil gas permeability test, an in situ respiration test will be conducted. Air will be injected into selected monitoring points to

aerate the soils. The in situ oxygen utilization and carbon dioxide production rates will be measured.

- The data from the soil gas permeability and in situ respiration tests will be used to determine an air injection/withdrawal rate for the bioventing test. A blower will be selected, installed, and operated for 6 to 12 months, and periodic measurements of the soil gas composition will be made to evaluate the long-term effectiveness of bioventing.

1.2 Site Descriptions

Hanscom AFB is located in Bedford, Massachusetts. A schematic diagram of the base is shown in Figure 1. The dashed lines on the map indicate the direction from the main gate to each test site. Site H1 and Site H2 refer to Building 1639 and Building 1812, respectively. Groundwater at Hanscom AFB generally is encountered at 3 to 8 feet. The sites chosen for the bioventing test initiative are Building 1639 and Building 1812. A brief description of the sites is provided in Sections 1.2.1 and 1.2.2. A detailed description of the test sites is provided in the Test Plan in Appendix A.

1.2.1 Building 1639 Site

Building 1639 is the base fuel service station (Figure 2). There have been three reported petroleum releases (gasoline, #2 fuel oil, and waste lubricating oil) at this facility since November 1990. Soil contamination at Building 1639 ranges from 599 ppm to 4,400 ppm TPH.

1.2.2 Building 1812 Site

The site at Building 1812 was the location of a heating oil fuel tank (Figure 3). Leakage occurred from the tank, resulting in soil contamination at this site. The tank was replaced recently, and soil TPH concentrations as high as 2,830 mg/kg have been reported.

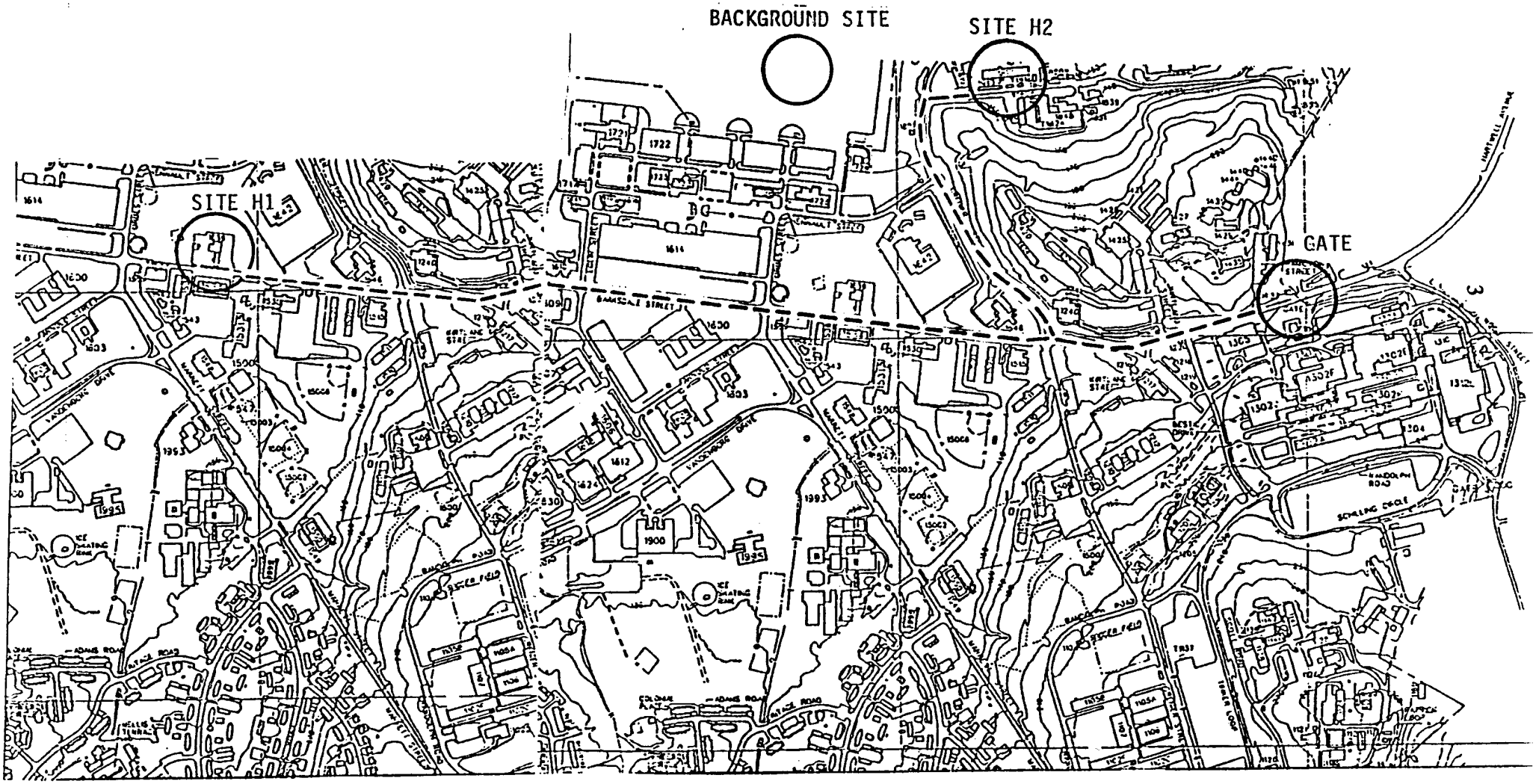

Figure 1. Schematic Diagram of Hanscom AFB

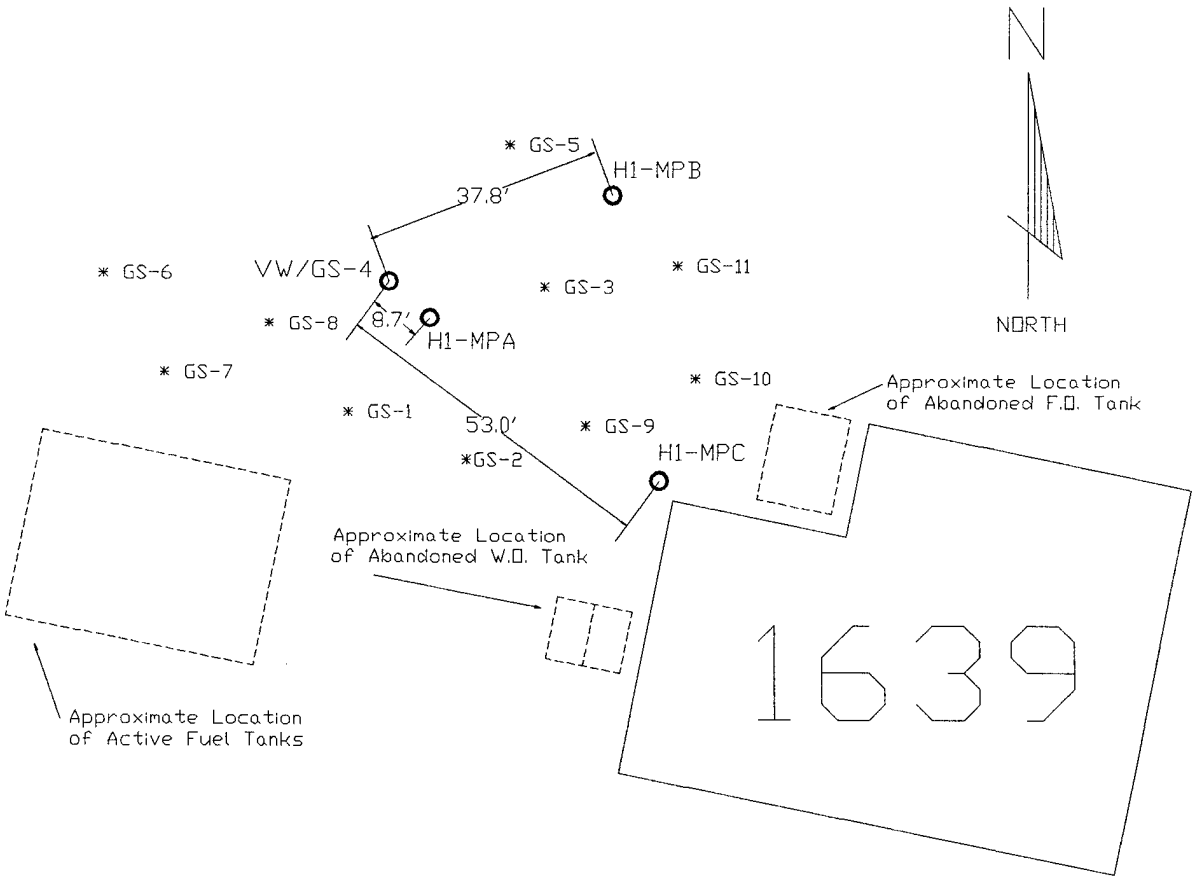

Figure 2. Schematic Diagram of Building 1639 at Hanscom AFB (GS - Soil Gas Survey Point; MP - Monitoring Point)

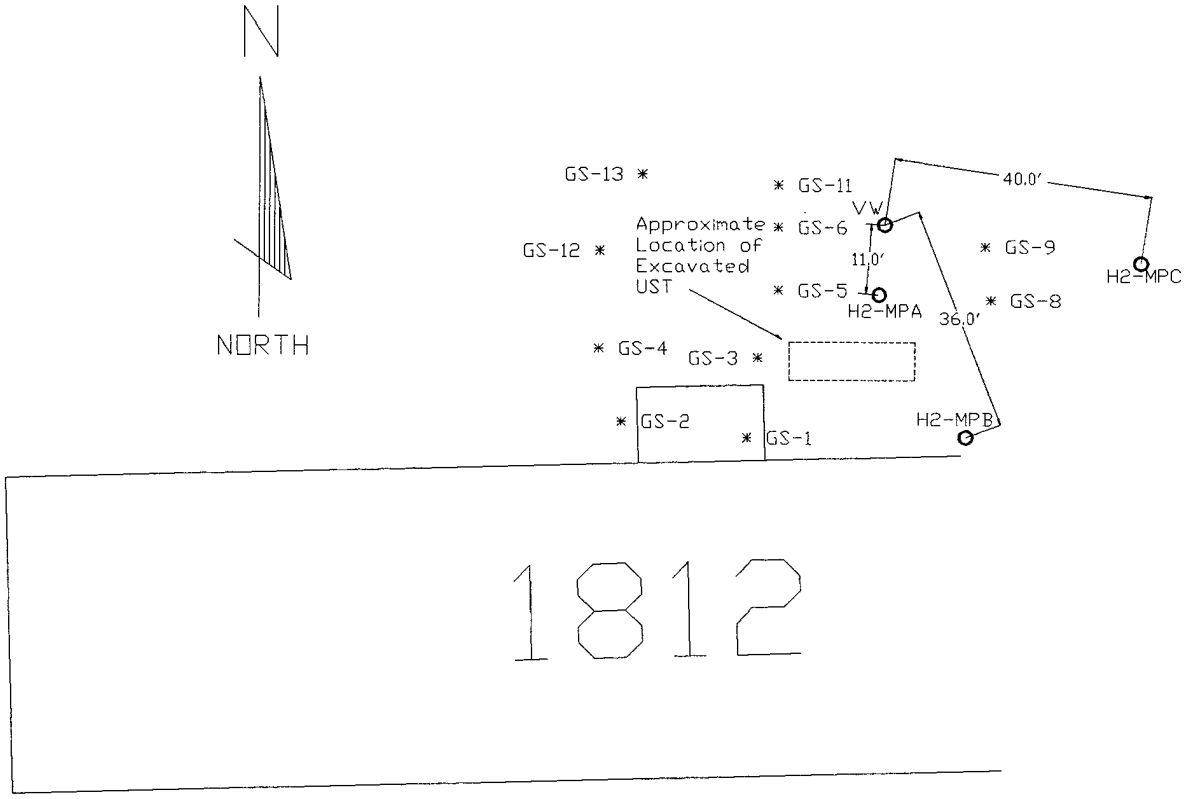

Figure 3. Schematic Diagram of Building 1812 at Hanscom AFB (GS - Soil Gas Survey Point; MP - Monitoring Point)

2.0 BUILDING 1639

2.1 Chronology of Events and Site Activities

2.1.1 Groundwater Measurements

One groundwater monitoring well (12BO3) was present at Building 1639. Groundwater level was measured at this well on September 30, 1992 and was recorded at 5.75 feet.

2.1.2 Soil Gas Survey

A suitable site for the bioventing demonstration should have soil gas characteristics of high TPH, low oxygen, and high carbon dioxide concentrations. This composition of soil gas would indicate that oxygen-limiting conditions for microbial activity are present and that the introduction of air may enhance biodegradation of TPH.

On September 30, 1992, a limited soil gas survey was conducted at Building 1639. Soil gases were sampled by driving a ⅝-inch-diameter stainless steel probe into the soil with a hammer drill. Soil gas was withdrawn with a vacuum pump and analyzed for oxygen, carbon dioxide, and TPH.

Measurements of oxygen and carbon dioxide in the soil gas were made with a GasTech Model 32520X with oxygen and carbon dioxide ranges of 0 to 25%. The analyzer was calibrated daily against atmospheric oxygen, atmospheric carbon dioxide, a 10% oxygen calibration standard, and a 5% carbon dioxide calibration standard. TPH was measured with a GasTech Trace Techtor with TPH ranges from 0 to 100, 0 to 1,000, and 0 to 10,000 ppm. The GasTech Trace Techtor was calibrated daily against a 4,200 ppm hexane standard.

The soil gas probes were driven to depths ranging from 2.5 to 5.0 feet at several locations at Building 1639. Table 1 provides the initial concentrations of oxygen, carbon dioxide, and TPH for the various locations at Building 1639. Oxygen concentrations varied from 0.8 to 21%, whereas TPH concentrations ranged from 410 ppm to greater than 20,000 ppm. The oxygen concentrations in the soil gas indicate that some areas at this site are oxygen-limited and may respond to bioventing.

Table 1. Initial Soil Gas Composition at Building 1639

Soil Gas Survey (GS) Point	Depth (ft)	Oxygen (%)	Carbon Dioxide (%)	TPH (ppm)
GS-1	2.5	19.0	2.5	15,600
	5.0	20.2	0.70	6,000
GS-2	2.5	16.0[1]	5.8	>20,000
	5.0	2.0	18.5	>20,000
GS-3	2.5	1.0	18.5	>20,000
	5.0	3.0	17.0	>20,000
GS-4	2.5	21.0[1]	0.10	920
	5.0	1.0	23.0	>20,000
GS-5	2.5	16.2	5.8	660
	5.0	15.0	7.0	720
GS-6	2.5	20.0	1.8	410
GS-7	2.5	21.0	0.50	900
GS-8	2.5	19.5[1]	1.0	5,600
	5.0	19.2[1]	1.8	8,800
GS-9	2.5	4.0[1]	13.5	>20,000
	5.0	0.80[1]	19.5	>20,000
GS-10	2.5	13.5[1]	6.8	>20,000
	5.0	0.80[1]	17.0	>20,000
GS-11	2.5	16.0[1]	4.3	>20,000

[1] Pressure reading on sampling pump was high. Measured oxygen concentration may not be representative of actual soil gas oxygen concentrations. Actual oxygen concentration is likely to be lower.

2.1.3 Vent Well, Monitoring Point, and Thermocouple Installation

On October 3, 1992, one vent well (VW) and three monitoring points (MPs) were installed, and soil samples were collected for analyses. The monitoring points were labeled as follows: H1-MPA; H1-MPB; and H1-MPC. The locations of the vent well and monitoring points are shown in Figure 2. A cross section of the vent well and monitoring points showing site lithology and construction detail is shown in Figure 4.

The vent well was installed at a depth of 7.0 feet into an 8-inch-diameter borehole. The vent well consisted of Schedule 40 2-inch-diameter polyvinyl chloride (PVC) piping with 3.0 feet of ten-slot screen. The annular space corresponding to the screened area of the well was filled with silica sand, and the annular space above the screened interval was filled with bentonite to prevent short-circuiting of air to or from the surface.

Soil gas probes consisted of ¼-inch tubing with a 1-inch-diameter, 6-inch screened area. The annular space corresponding to the screened area was filled with silica sand, whereas the interval between the screened areas was filled with bentonite, as was the annular space from the shallowest monitoring point to the ground surface. The monitoring points were installed at depths as follows:

- Monitoring point H1-MPA was installed at a depth of 5.0 feet into an 8-inch-diameter borehole. The monitoring point was screened to two depths: 2.5 and 5.0 feet.
- Monitoring point H1-MPB was installed at a depth of 5.0 feet into an 8-inch-diameter borehole. The monitoring point was screened to two depths: 2.5 and 5.0 feet.
- Monitoring point H1-MPC was installed at a depth of 6.0 feet into an 8-inch-diameter borehole. The monitoring point was screened to two depths: 3.5 and 6.0 feet.

A Type K thermocouple was installed with monitoring points H1-MPA-2.5′ and H1-MPA-5.0′.

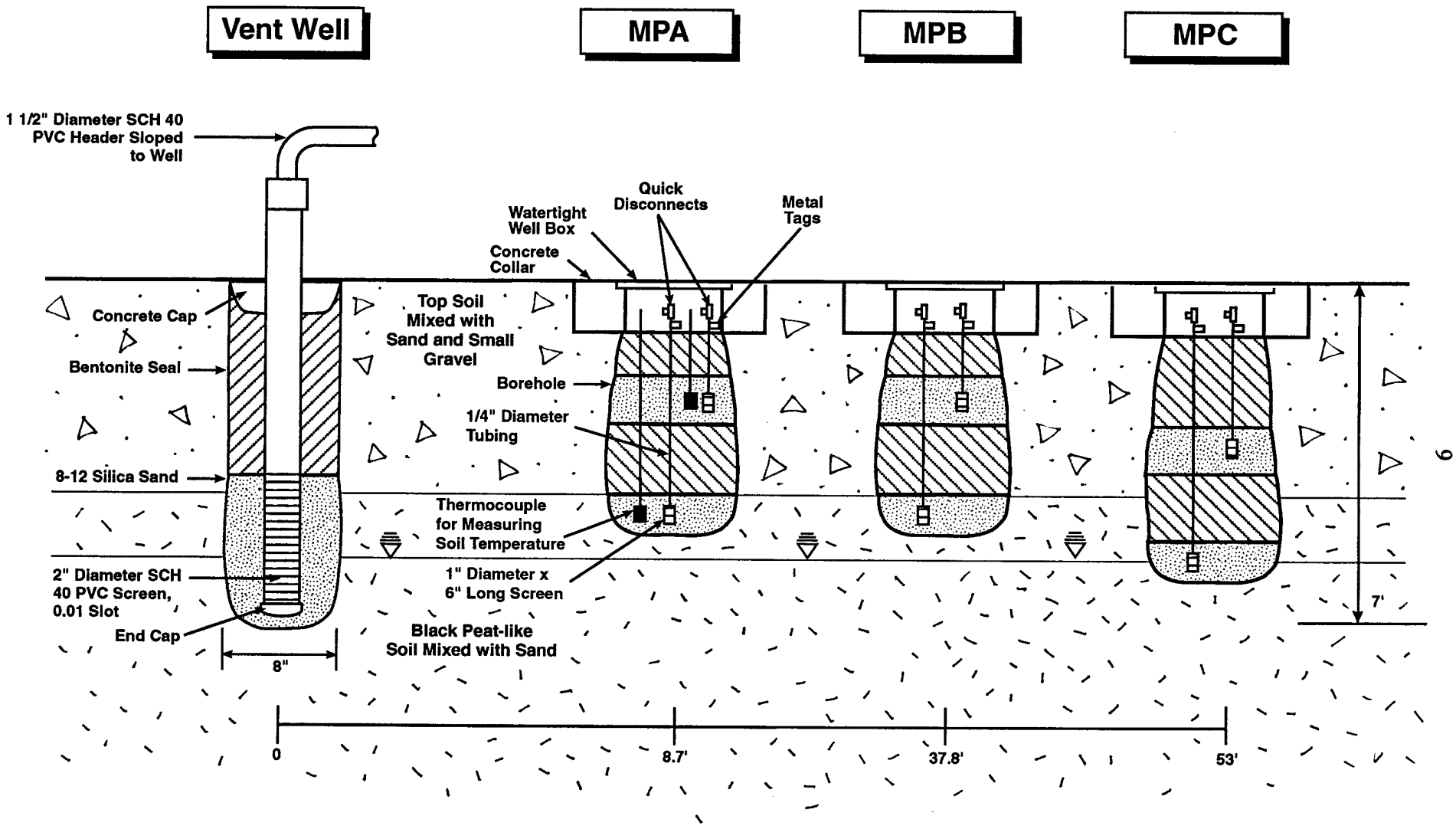

Figure 4. Cross Section of Vent Well and Monitoring Points at Building 1639 Showing Site Lithology and Construction Detail (not to scale)

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2.1.4 Soil and Soil Gas Sampling and Analyses

Split-spoon soil samples were collected at depths of 4.0 to 4.5 feet and 4.5 to 5.0 feet from the vent well borehole and were labeled H1-VW-4'-4.5' and H1-VW-4.5'-5.0', respectively. A soil sample also was collected from monitoring point A at a depth of 3.0 to 4.0 feet and was labeled H1-A-3'-4'. The samples were sent under chain of custody to Engineering-Science Inc., Berkeley Laboratory for analysis of benzene, toluene, ethylbenzene, and xylenes (BTEX); TPH; alkalinity; moisture content; pH; iron; total phosphorous; total Kjeldahl nitrogen; and particle size analysis.

Soil vapor samples were collected from all monitoring points and were labeled H1-A-2.5, H1-A-5, H1-B-2.5, H1-B-5, H1-C-3.5, and H1-C-6. These samples were sent under chain of custody to Air Toxics, Ltd., in Rancho Cordova, California, for analysis of BTEX and TPH.

2.1.5 Soil Gas Permeability and Radius of Influence

A detailed description of the method for conducting a soil gas permeability test, including equations to compute k, the soil gas permeability, is given in the Test Plan and Technical Protocol (Hinchee et al., 1992).

Prior to air injection, the monitoring points were allowed to set up for 24 hours. Air was injected with a portable 1-horsepower (HP) explosion-proof positive displacement blower unit. After air injection was initiated, pressure readings were taken approximately every 1 to 2 minutes for the first hour, then approximately every 10 minutes for the following hour. The Hyperventilate™ computer model was used to calculate the soil gas permeability.

2.1.6 In Situ Respiration Test

Immediately following the soil gas permeability test, air containing approximately 1% helium was injected into the soil for approximately 24 hours, beginning on October 6. Air was injected concurrently into the background monitoring well to measure the natural biodegradation of organic material in the soil. The setup for the in situ respiration test is described in the Test Plan and Technical Protocol (Hinchee et al., 1992). The pump used for air injection was a ⅓-HP diaphragm pump. Air and helium were injected through the following monitoring points at the depths indicated: H1-MPA-5.0'; H1-MPB-2.5'; H1-MPB-5.0'; and H1-MPC-6.0'. After the air/helium injection was

turned off, the respiration gases were monitored periodically. The respiration test was terminated on October 10.

Helium concentrations were measured during the in situ respiration test to quantify helium leakage to or from the surface around the monitoring points. Helium loss over time is attributed to either diffusion or leakage. A rapid drop in helium concentration followed by a leveling is an indication of leakage. A gradual loss along with an apparent first-order curve is an indicator of diffusion. As a rough estimate, the diffusion of gas molecules is inversely proportional to the square root of the molecular weight of the gas. Based on molecular weights of 4 for helium and 32 for oxygen, helium gas diffuses about 2.8 times faster than oxygen, or the diffusion of oxygen is 0.35 times the rate of helium diffusion. As a general rule, we have found that if helium concentrations are at least 50 to 60% of the initial levels at test completion, measured oxygen uptake rates are representative. Greater helium loss indicates a problem, and oxygen utilization rates are not considered representative.

To compare data from one site to another, a stoichiometric relationship of the oxidation of the hydrocarbon was assumed. Hexane was used as the representative hydrocarbon for the organic contaminant. The stoichiometric relationship is given by:

$$C_6H_{14} + 9.5O_2 \rightarrow 6CO_2 + 7H_2O \qquad (1)$$

Based on the utilization rates (% per day), the biodegradation rates in terms of milligrams as a hexane equivalent per kilogram of soil per day were computed using the equation below by assuming a soil porosity of 0.2 and a bulk density of 1,440 kg/m^3.

$$K_\beta = \frac{-K_o A D_o C}{100} \qquad (2)$$

where: K_β = biodegradation rate (mg/kg/day)

K_o = oxygen utilization rate (percent per day)

A = volume of air/kg of soil, in this case 300/1,440 = 0.21

D_o = density of oxygen gas (mg/L) assumed to be 1,330 mg/L

C = mass ratio of hydrocarbon to oxygen required for mineralization, assumed to be 1/3.5 from the above stoichiometric equation.

2.2 Results and Discussion

2.2.1 Soil and Soil Gas Analyses

Results of the soil analyses for BTEX and TPH at Building 1639 are presented in Table 2. The analytical report for this site is presented in Appendix B. Concentrations of the BTEX compounds in soil samples ranged from 0.015 mg/kg (ethylbenzene) up to 12 mg/kg (total xylenes), whereas TPH concentrations ranged from below the detection limit (<0.0040 mg/kg) to 22 mg/kg. The soil vapor analyses also showed similar measurements of BTEX and TPH, with concentrations of TPH ranging from 280 ppmv to 19,000 ppmv and from 0.11 ppmv (ethylbenzene) up to 67 ppmv (total xylenes) of the BTEX compounds (Table 2). The results of the soil chemistry analyses are summarized in Table 3.

2.2.2 Soil Gas Permeability and Radius of Influence

The raw data for the soil gas permeability test at Building 1639 are presented in Appendix C. Using the Hyperventilate™ computer model, soil gas permeabilities were calculated at each of the monitoring points. These data are presented in Table 4. The soil gas permeability varied considerably, with values ranging from 24 darcy up to 5.4×10^8 darcy. Typically, the radius of influence is calculated by plotting the log of the pressure change at a specific monitoring point versus the distance from the vent well. The radius of influence would then be the distance where 1 inch of water pressure can be measured. However, in this instance, 1 inch of water pressure was not achieved at any monitoring point (Figure 5); therefore, a radius of influence based on these specifications cannot be definitively determined at this site, other than to say it is less than 8.7 feet.

2.2.3 In Situ Respiration Test

The results of the in situ respiration test for Building 1639 are presented in Appendix D. Each figure in Appendix D illustrates the oxygen, carbon dioxide, and helium concentrations as a

Table 2. Results From Soil and Soil Gas Analyses for BTEX and TPH at Building 1639

Matrix	Sample Name	Benzene (mg/kg)	Toluene (mg/kg)	Ethylbenzene (mg/kg)	Total Xylenes (mg/kg)	TPH[1] (mg/kg)
Soil	H1-VW-4′-4.5′	0.048	0.020	0.015	0.020	22
	H1-VW-4.5′-5.0′	0.67	0.27	0.43	0.45	15
	H1-A-3′-4′	1.0	4.3	1.3	12	<0.0040
Matrix	**Sample Name**	**Benzene (ppmv)**	**Toluene (ppmv)**	**Ethylbenzene (ppmv)**	**Total Xylenes (ppmv)**	**TPH[2] (ppmv)**
Soil Gas	H1-A-2.5	5.2	4.2	1.1	2.9	5,600
	H1-A-5	27	35	10	30	19,000
	H1-B-2.5	2.8	1.3	0.84	1.9	2,700
	H1-B-5	2.4	0.84	0.42	1.5	3,200
	H1-C-3.5	0.44	0.13	0.11	0.37	280
	H1-C-6	11	20	9.3	67	11,000

[1] Referenced to a reference oil composed of a mixture of 2,2,4-trimethylpentane, *n*-hexadecane, and chlorobenzene.

[2] TPH referenced to jet fuel (molecular weight = 156).

Table 3. Results From Soil Chemistry Analyses at Building 1639

Parameter	Sample Name		
	H1-VW-4'-4.5'	H1-VW-4.5'-5.0'	H1-A-3'-4'
Alkalinity (mg/kg $CaCO_3$)	<50	<50	<50
Moisture (% by weight)	22.2	21.8	5.8
pH	5.8	6.0	6.1
Iron (mg/kg)	7,980	6,260	8,630
Total Phosphorous (mg/kg)	370	290	300
Total Kjeldahl Nitrogen (mg/kg)	1,100	730	70
Particle Size Analysis (%)	Gravel: 11.5	Gravel: 0.5	Gravel: 26
	Sand: 59	Sand: 72	Sand: 55
	Silt: 27	Silt: 23	Silt: 16
	Clay: 6	Clay: 4.5	Clay: 3

Table 4. Results of Hyperventilate™ Soil Gas Permeability Analysis at Building 1639

Monitoring Point	Depth (ft)	Soil Gas Permeability (darcy)
H1-MPA	2.5	24
	5.0	130
H1-MPB	2.5	1,400
	5.0	6,200
H1-MPC	3.5	5.4×10^8
	6.0	28

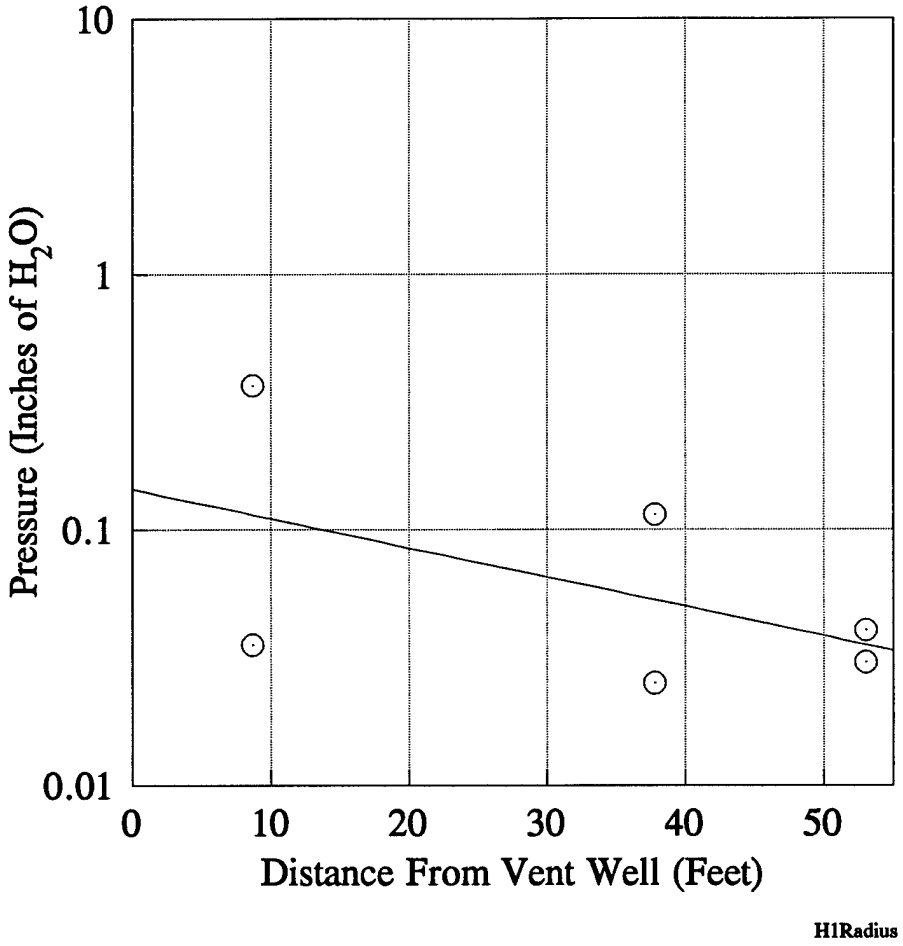


Figure 5. Radius of Influence at Building 1639

function of time. An example of typical oxygen utilization at this site is shown in Figure 6, where oxygen utilization and carbon dioxide production at monitoring point H1-MPA-5.0′ is illustrated. A summary of the oxygen utilization and carbon dioxide production rates and corresponding biodegradation rates is shown in Table 5. The biodegradation rates measured at this site were fairly high, with rates ranging from 8.0 mg/kg/day to 27 mg/kg/day based on oxygen utilization, and from 0.48 mg/kg/day to 4.3 mg/kg/day based on carbon dioxide production.

Loss of helium was insignificant at all monitoring points, indicating that the monitoring points were well sealed and that the oxygen depletion observed was a result of biodegradation.

Soil temperatures were measured during the in situ respiration test. Temperatures during the test ranged from 17.9 to 19.3°C at monitoring point H1-MPA-2.5′ and from 18.7 to 20.7°C at monitoring point H1-MPA-5.0′.

2.2.4 Bioventing Demonstration

The decision was made to install a bioventing system at Building 1639. A 1-HP blower was installed at the site on October 14, 1992. Air injection was initiated on October 14 at a flowrate of 2.5 scfm.

Table 5. Oxygen Utilization and Carbon Dioxide Production Rates During the In Situ Respiration Test at Building 1639

Monitoring Point	Oxygen Utilization Rate (%/hour)	Biodegradation Rate (mg/kg/day)	Carbon Dioxide Production Rate (%/hour)	Biodegradation Rate (mg/kg/day)
Background	0.0073	0.14	0.0087	0.19
H1-MPA-5.0′	1.4	27	0.076	1.6
H1-MPB-2.5′	0.42	8.0	0.034	0.74
H1-MPB-5.0′	0.58	11	0.022	0.48
H1-MPC-6.0′	0.69	13	0.20	4.3

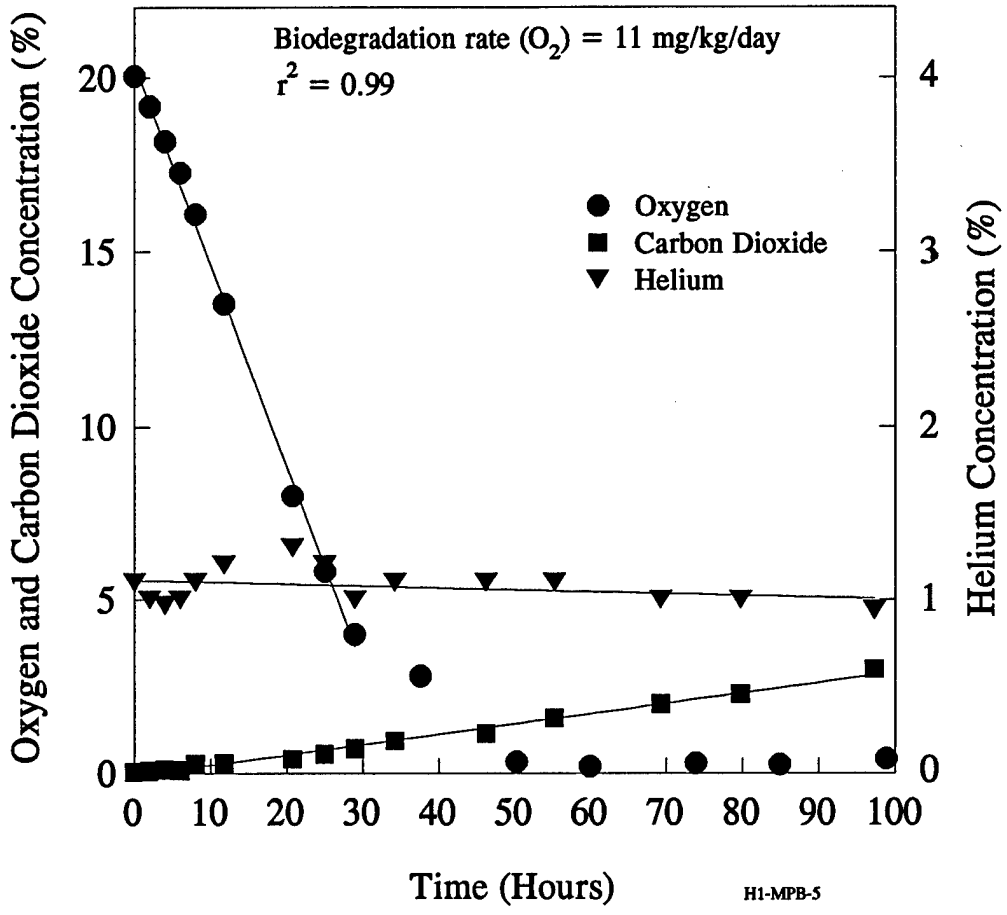


Figure 6. Oxygen Utilization and Carbon Dioxide Production During the In Situ Respiration Test at Monitoring Point H1-MPB-5.0′

3.0 BUILDING 1812

3.1 Chronology of Events and Site Activities

Although oxygen levels measured during the soil gas survey indicated that some areas at the Building 1812 site may be limited, oxygen concentrations measured at the permanent monitoring points were fairly high. Therefore, an in situ respiration test was not conducted at this site. However, because measurements taken during the soil gas survey indicated that some areas were oxygen-limited, a bioventing system was installed at the site in order to treat those areas. Other activities were conducted at the site according to the Test Plan and Technical Protocol (Hinchee et al., 1992).

3.1.1 Groundwater Measurements

Groundwater depth was measured at one monitoring well (HB-02) at Building 1812. The groundwater level was measured on October 1, 1992 and was recorded at 3.98 feet.

3.1.2 Soil Gas Survey

On October 1, 1992, a limited soil gas survey was conducted to locate a suitable test area at Building 1812. Soil gases were sampled by driving a ⅝-inch-diameter stainless steel probe into the soil with a hammer drill. Soil gas was withdrawn with a vacuum pump and analyzed for oxygen, carbon dioxide, and TPH. Soil gas measurements were taken as described in Section 2.1.2.

The soil gas probes were driven to depths ranging from 2.0 to 5.0 feet at several locations at Building 1812. Table 6 provides the initial concentrations of oxygen, carbon dioxide, and TPH for the various locations at Building 1812. Relatively high concentrations of oxygen were found at most of the soil gas probes, with concentrations ranging from 3 to 20%. Relatively low concentrations of carbon dioxide (0.05 to 8.5%) and TPH (10 ppm to 800 ppm) were encountered. The oxygen concentrations in the soil gas indicate that some areas at this site are oxygen-limited and may respond to bioventing.

Table 6. Initial Soil Gas Composition at Building 1812

Monitoring Point	Depth (ft)	Oxygen (%)	Carbon Dioxide (%)	TPH (ppm)
GS-1	2.5	19.5	0.7	120
GS-2	2.5	20	0.05	10
	5.0	NS	NS	NS
GS-3	2.25	20.2	0.60	87
GS-4	2.5	17	0.30	40
	4.0	19.8[1]	0.08	20
GS-5	2.5	15	3.8	220
	5.0	13	5.1	270
GS-6	2.5	16.5	1.3	120
	5.0	NS	NS	NS
GS-7	2.0	9.1	6.0	440
	3.5 - 4.0	7.0	7.2	480
GS-8	2.5	17.5	1.2	250
GS-9	2.0	17	1.4	280
GS-10	2.0	3.0	8.5	800
GS-11	2.0	18.8	0.40	180
	3.0	18.3	0.60	96
	4.0	18.9[1]	2.7	220
GS-12	2.0	17	0.10	41
	3.0	18	0.70	120
	4.0	17.5	0.10	50

NS Not sampled. Groundwater was encountered at this depth.

[1] Pressure reading on sampling pump was high. Measured oxygen concentration may not be representative of actual soil gas oxygen concentrations. The actual oxygen concentration is likely to be lower.

3.1.3 Vent Well, Monitoring Point, and Thermocouple Installation

On October 4, 1992, one vent well and three monitoring points were installed, and soil samples were collected for analyses. The monitoring points were labeled H2-MPA, H2-MPB, and H2-MPC. The locations of the vent well and monitoring points are shown in Figure 3. A cross section of the vent well and monitoring points showing site lithology and construction detail is shown in Figure 7.

The vent well was installed at a depth of 7.0 feet into an 8-inch-diameter borehole. The vent well consisted of Schedule 40 2-inch-diameter PVC piping with 3.6 feet of ten-slot screen. The annular space corresponding to the screened area of the well was filled with silica sand, whereas the annular space above the screened interval was filled with bentonite to prevent short-circuiting of air to or from the surface.

Soil gas probes consisted of ¼-inch tubing with a 1-inch-diameter, 6-inch screened area. The annular space corresponding to the screened area was filled with silica sand, whereas the interval between the screened areas was filled with bentonite, as was the annular space from the shallowest monitoring point to the ground surface. The monitoring points were installed at depths as follows:

- Monitoring point H2-MPA was installed at a depth of 5.0 feet into an 8-inch-diameter borehole. The monitoring point was screened to two depths: 2.5 and 5.0 feet.
- Monitoring point H2-MPB was installed at a depth of 7.0 feet into an 8-inch-diameter borehole. The monitoring point was screened to three depths: 2.5, 5.0, and 7.0 feet.
- Monitoring point H2-MPC was installed at a depth of 6.0 feet into an 8-inch-diameter borehole. The monitoring point was screened to three depths: 2.5, 4.5, and 6.0 feet.

A Type K thermocouple was installed with monitoring points H2-MPA-2.5′ and H2-MPA-5.0′.

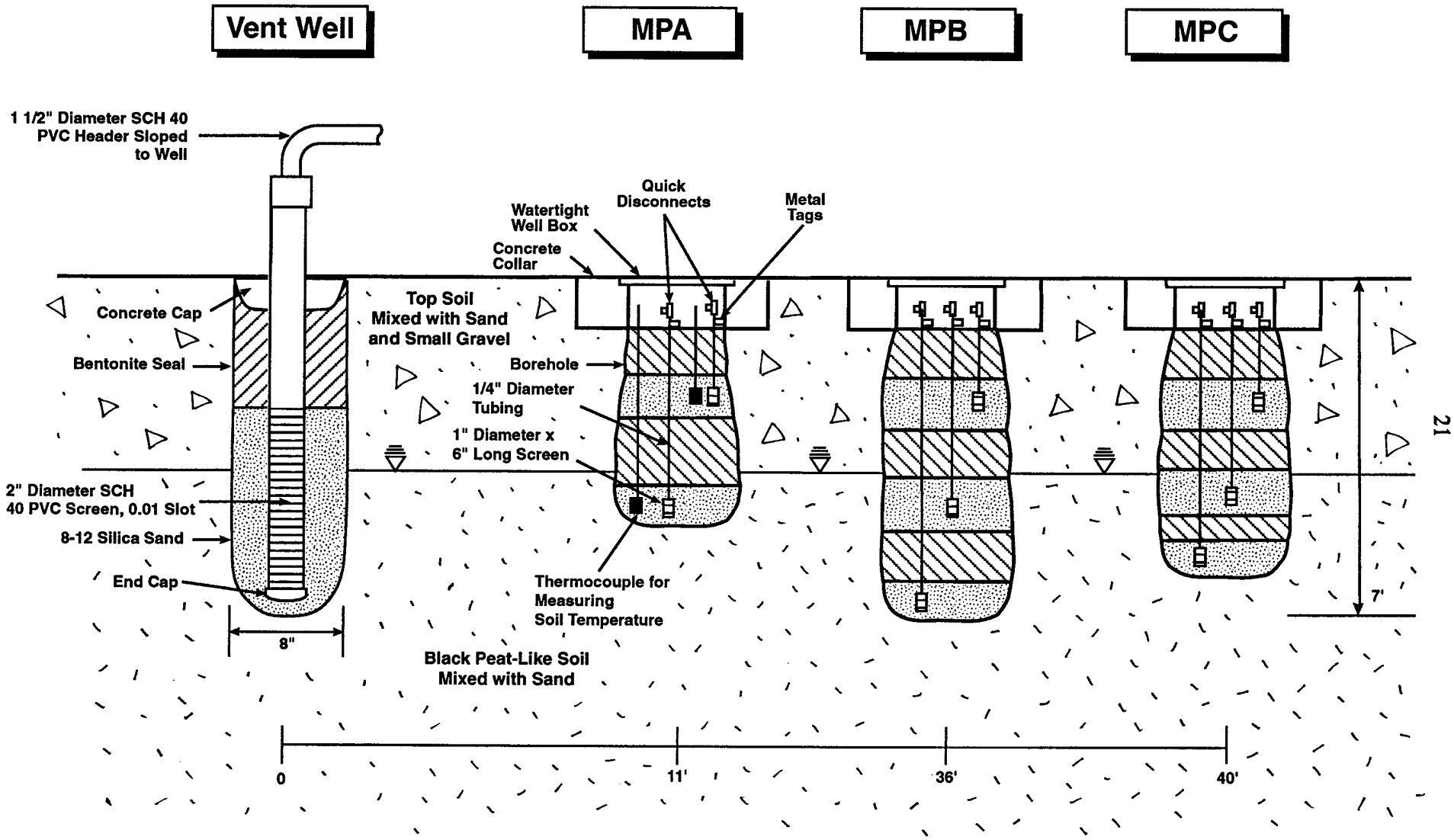


Figure 7. Cross Section of Vent Well and Monitoring Points at Building 1812 Showing Site Lithology and Construction Detail (not to scale)

F/Kittel11/h-2

3.1.4 Soil and Soil Gas Sampling and Analyses

Split-spoon soil samples were collected at depths of 3.0 to 3.5 feet and 4.0 to 4.5 feet from the vent well borehole and were labeled H2-VW-3'-3.5' and H2-VW-4'-4.5', respectively. The samples were sent under chain of custody to Engineering-Science Inc., Berkeley Laboratory for analyses of BTEX; TPH; alkalinity; moisture content; pH; iron; total phosphorous; total Kjeldahl nitrogen; and particle size analysis.

3.1.5 Soil Gas Permeability and Radius of Influence

A detailed description of the method for conducting a soil gas permeability test, including equations to compute k, the soil gas permeability, is given in the Test Plan and Technical Protocol (Hinchee et al., 1992).

Prior to air injection, the monitoring points were allowed to set up for 24 hours. A portable 1-HP explosion-proof positive displacement blower unit was used to inject air. After air injection was initiated, pressure readings were taken approximately every 1 to 2 minutes for the first hour, then approximately every 10 minutes for the following hour. The Hyperventilate™ computer model was used to calculate the soil gas permeability.

3.2 Results and Discussion

3.2.1 Soil and Soil Gas Analyses

Results of the soil analyses for BTEX and TPH are presented in Table 7. The analytical report for this site is presented in Appendix B. All of the BTEX compounds were at concentrations below the detection limit in sample H1-VW-3'-3.5' and only small quantities of toluene (0.015 mg/kg) and total xylenes (0.051 mg/kg) were detected in sample H1-VW-4'-4.5'. TPH concentrations were low in sample H1-VW-3'-3.5' (12 mg/kg); however, 13,000 mg/kg of TPH was detected in sample H1-VW-4'-4.5'. The results of the soil chemistry analyses are summarized in Table 8.

Table 7. Results From Soil Analyses for BTEX and TPH at Building 1812

Sample Name	Benzene (mg/kg)	Toluene (mg/kg)	Ethylbenzene (mg/kg)	Total Xylenes (mg/kg)	TPH[1] (mg/kg)
H2-VW-3′-3.5′	<0.062	<0.072	<0.052	<0.093	12
H2-VW-4′-4.5′	<0.0032	0.015	<0.0026	0.051	13,000

[1] Referenced to a reference oil composed of a mixture of 2,2,4-trimethylpentane, *n*-hexadecane, and chlorobenzene.

Table 8. Results From Soil Chemistry Analysis at Building 1812

Parameter	Sample Name	
	H2-VW-3′-3.5′	H2-VW-4′-4.5′
Alkalinity (mg/kg $CaCO_3$)	90	<50
Moisture (% by weight)	3.2	6.1
pH	7.0	6.2
Iron (mg/kg)	8,160	5,460
Total Phosphorous (mg/kg)	450	600
Total Kjeldahl Nitrogen (mg/kg)	66	53
Particle Size Analysis (%)	Gravel: 10	Gravel: 1.0
	Sand: 69.5	Sand: 76
	Silt: 19	Silt: 21.5
	Clay: 1.5	Clay: 1.5

3.2.2 Soil Gas Permeability and Radius of Influence

The raw data for the soil gas permeability test at Building 1812 are presented in Appendix E. Using the Hyperventilate™ computer model, soil gas permeabilities were calculated at each of the monitoring points. These data are presented in Table 9. The soil gas permeability varied considerably, with values ranging from 2.5 darcy up to 6.3×10^9 darcy. The radius of influence where 1 inch of water could be measured was calculated by plotting the log of the pressure change at the monitoring points versus the distance from the vent well (Figure 8). If pressure changes at all monitoring points are included, no radius of influence can be calculated based on these specifications. However, if the pressure change at monitoring points below the water table are not included (H2-MPA-5.0′ and H2-MPB-5.0′), the radius of influence at Building 1812 is estimated to be approximately 7.5 feet.

3.2.3 Bioventing Demonstration

The decision was made to install a bioventing system at Building 1812. A 1-HP blower was installed on October 14, 1992. Air injection was initiated on October 14 at a flowrate of 4.25 scfm.

4.0 BACKGROUND AREA ACTIVITIES

The background area was located as shown in Figure 1. An existing monitoring well was used as the vent well and was screened from 1.5 feet to 9.0 feet. Soil samples were taken 2 feet from the monitoring well by hand auger. Site lithology at this area was representative of that in the contaminated areas.

A split-spoon soil sample was collected at a depth of 2.5 to 3.0 feet from the vent well borehole and was labeled H1-BKG-2.5′-3′. A soil vapor sample also was collected from the vent well after installation and labelled H1-BG-1.5-9. The soil samples were sent under chain of custody to Engineering-Science Inc., Berkeley Laboratory for analysis of BTEX; TPH; alkalinity; moisture content; pH; iron; total phosphorous; total Kjeldahl nitrogen; and particle size analysis. The soil vapor sample was sent under chain of custody to Air Toxics, Ltd., in Rancho Cordova, California, for analysis of BTEX and TPH.

Table 9. Results of Hyperventilate™ Soil Gas Permeability Analysis

Monitoring Point	Depth (ft)	Soil Gas Permeability (darcy)
H2-MPA	2.5	6.3×10^9
	5.0	2.5
H2-MPB	2.5	3.1×10^9
	5.0	430
	7.0	ND
H2-MPC	2.5	NR
	4.5	NR
	6.0	NR

ND No data were collected from this monitoring point.
NR No pressure readings were detected at this monitoring point.

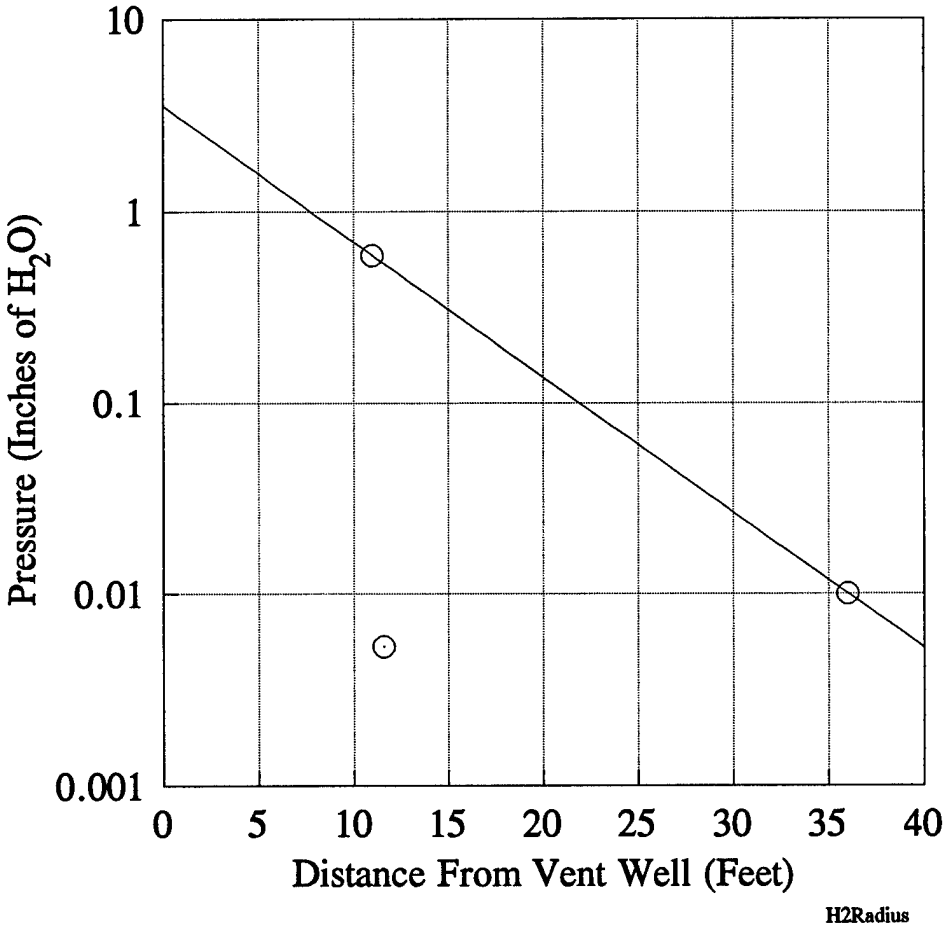


Figure 8. Radius of Influence at Building 1812

Results of the soil and soil vapor analyses for BTEX and TPH are presented in Table 10. The analytical report for the background area is presented in Appendix B. All of the BTEX compounds were at concentrations below the detection limit in the soil sample, and only a small quantity of TPH (84 mg/kg) was detected. The soil vapor sample contained higher concentrations of BTEX compounds with concentrations ranging from 0.16 ppmv (benzene) up to 4.7 ppmv (total xylenes). The results of the soil chemistry analyses also are summarized in Table 10.

An in situ respiration test was conducted at the background area beginning on October 9 after 24 hours of air injection. The test was concluded on October 11. Very little decrease in oxygen concentration occurred during the course of the in situ respiration test (Figure 9).

5.0 FUTURE WORK

Base personnel will be required to perform a simple weekly system check to ensure that the blower is operating within its intended flowrate, pressure, and temperature range. An on-site briefing for base personnel who will be responsible for blower system checks was conducted when the blowers were installed. The principle of operation was explained, and a simple checklist and logbook were provided for blower data. Base personnel will be asked to perform minor maintenance activities, such as replacing filters or gauges, or draining condensate from knockout chambers, but they will not be expected to perform complicated repairs or analyze gas samples. Replacement filters and gauges will be provided and shipped to the base, and serious problems, such as motor or blower failures, will be corrected by Battelle.

The progress of this system will be monitored by conducting semiannual respiration tests in the vent well and in each monitoring point and by regularly measuring the oxygen, carbon dioxide, and hydrocarbon concentrations in the extracted soil gas and comparing them to background levels. At least twice each year, the progress of the bioventing test will be reported to the base point-of-contact.

Table 10. Results From Soil Chemistry Analysis at Background Area

Parameter	Sample Name	
	Soil Sample H1-BKG-2.5'-3'	Soil Vapor Sample H1-BG-1.5-9
Benzene	<0.00060 mg/kg	0.16 ppmv
Toluene	<0.00070 mg/kg	0.93 ppmv
Ethylbenzene	<0.00050 mg/kg	0.43 ppmv
Total Xylenes	<0.00090 mg/kg	4.7 ppmv
TPH	84 mg/kg	340 ppmv
Alkalinity (mg/kg $CaCO_3$)	<50	
Moisture (% by weight)	9.8	
pH	6.6	
Iron (mg/kg)	11,600	
Total Phosphorous (mg/kg)	460	
Total Kjeldahl Nitrogen (mg/kg)	91	
Particle Size Analysis (%)	Gravel: 11.5	
	Sand: 48	
	Silt: 32	
	Clay: 8.5	

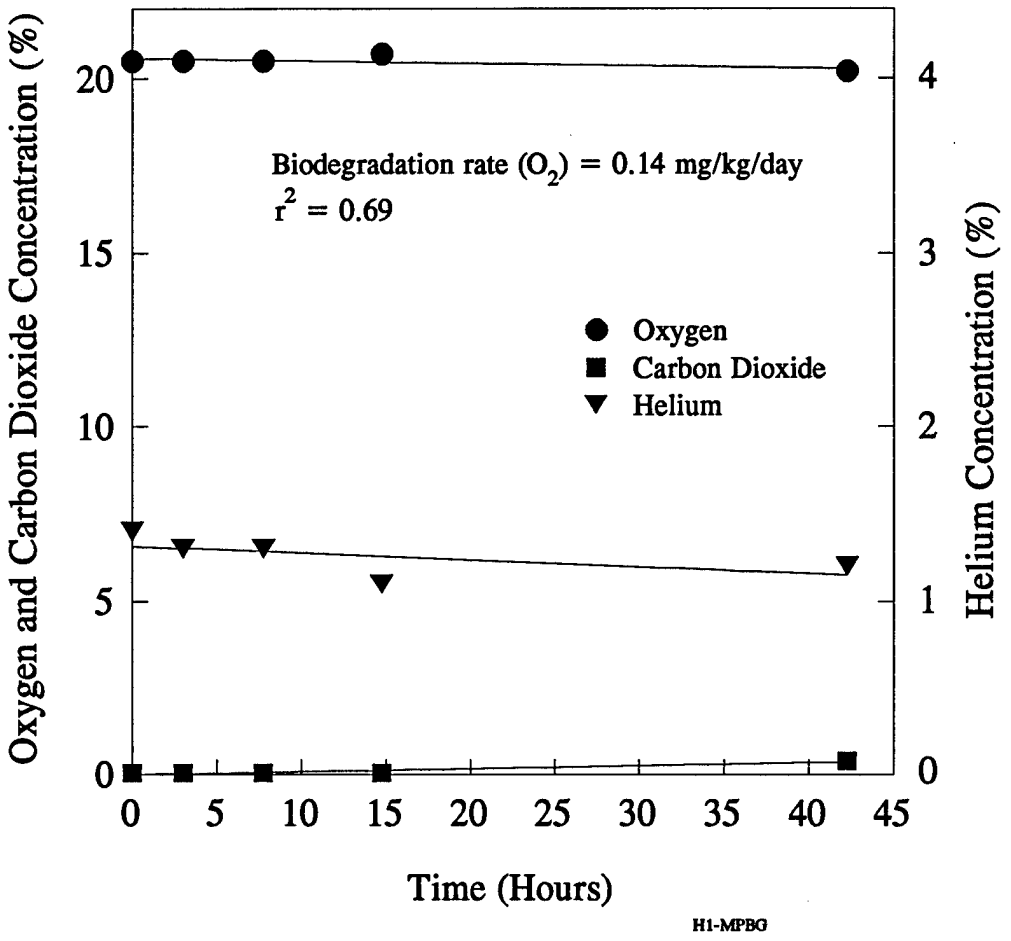


Figure 9. Oxygen Utilization and Carbon Dioxide Production During the In Situ Respiration Test at the Background Area

6.0 REFERENCE

Hinchee, R.E., S.K. Ong, R.N. Miller, D.C. Downey, and R. Frandt. 1992. *Test Plan and Technical Protocol for a Field Treatability Test for Bioventing* (Rev. 2), Report prepared by Battelle Columbus Operations, U.S. Air Force Center for Environmental Excellence, and Engineering Sciences, Inc. for the U.S. Air Force Center for Environmental Excellence, Brooks Air Force Base, Texas.

APPENDIX A

TEST PLAN FOR HANSCOM AFB, MASSACHUSETTS

Battelle
. . . Putting Technology To Work
505 King Avenue
Columbus, Ohio 43201-2693
Telephone (614) 424-6424
Facsimile (614) 424-5263

September 2, 1992

Captain Catherine Vogel
Department of the Air Force
Building 1117
HQ AFESC/RDVW
Tyndall AFB, Florida 32403-6001

Dear Cathy:

SUBJECT: TEST PLAN FOR BIOVENTING INITIATIVE FIELD TEST AT BUILDING 1639 AND BUILDING 1812, HANSCOM AFB, MA.

This letter was prepared to accompany the report titled "Test Plan and Technical Protocol for a Field Treatability Test for Bioventing." The report was developed as a generic test plan for the Air Force Bioventing Initiative Project in which Hansom AFB is participating. This letter outlines site specific information to support the generic test plan.

The sites chosen for the bioventing test initiative are Building 1639 and Building 1812. Building 1639 is the base fuel service station (see map Figure 1). There have been three reported petroleum releases (gasoline, #2 fuel oil, and waste lubricating oil) at this facility since November 1990. The site at Building 1812 is the location of a heating oil fuel tank (see Figure 2). The tank was replaced recently and soil TPH concentrations as high as 2830 mg/Kg have been reported.

The purpose of this project is to investigate the feasibility of using the bioventing technology to remediate petroleum contaminated soils at the above mentioned sites.

Site Description:

Hanscom AFB is located in Bedford, Massachusetts. A generalized geologic and hydrogeologic column is shown in Figure 3. Groundwater at Hanscom is encountered at 3-8 feet. Figures 4 and 5 show test boring logs for two soil borings in the vicinity of the bioventing initiative sites.

Soil contamination at Building 1639 ranges from 599 ppm to 4400 ppm TPH. Soil samples at Building 1812 have indicated TPH concentrations as high as 2800 ppm. Boring and depth locations for these samples were not immediately available. Locations for initiating the soil gas survey at each site will be determined with direction from the Base POC.

Project Activities-

The following field activities are planned for the bioventing project at Hanscom AFB. The same procedures will be followed at each site. Additional detail can be found in Section 5.0 of the test plan and technical protocol.

1- A small scale soil gas survey will be conducted to identify an appropriate location for installation of the bioventing system. The soil gas survey will be conducted in areas which site data have shown to be the most contaminated. Soil vapor from the candidate site should exhibit high petroleum hydrocarbon concentrations (10,000 ppm or greater), relatively low O_2 concentrations (0 % to 2.0 %), and relatively high CO_2 concentrations (depending on soil type, 2.0 % to 10.0 %, or higher). An uncontaminated background location will also be identified.

2- Once the installation sites are located one vent well and three 3-level soil gas monitoring points will be installed in the contaminated location and one vent well will be installed in a background area (one background area will be used for both test sites, if possible). The wells and monitoring points will be installed using a two-man power auger or a portable drill rig to bore down to just above the water table. Three to four soil samples will be collected for chemical/physical analysis.

3- The air permeability test will be conducted in the contaminated test location.

4- Following the air permeability test, in situ respiration tests will be conducted in both the contaminated and the background test locations.

5- Depending on the results of the air permeability test and the in situ respiration test, a decision will be made whether or not to install a blower system in the contaminated area for the long term bioventing test. If the decision is made to install the system, the blower will be plumbed to the vent well and bioventing will be started (assuming power is available). Site personnel will be trained for blower operation prior to Battelle leaving the site.

6- A report detailing the results of the in situ respiration test and the air permeability test will be provided to the project officer and the base POC.

Schedule-

Field activities at Hanscom AFB are planned to begin on September 28, 1992. Battelle will have 2 to 3 people on site for approximately 3 weeks.

Base Support-

Hanscom AFB needs to be able to provide the following:

- Digging permits and utility clearance need to be obtained prior to the initiation of the field work. Underground utilities should be clearly marked to reduce the chance of utility damage or personal injury during soil gas probe and well installation. Battelle will not be able to begin field operations without these clearances.

- Electrical power will need to be easily accessible from the project site. The air permeability test and in situ respiration test can be performed using a gasoline powered electric generator. The operation of the bioventing system will require a permanent 220/110 V power source. If power will not be available immediately after the test is completed the bioventing system will be installed for start-up at a later date.

- The Air Force will need to provide drums to contain soil cuttings and provide for contaminated soil disposal.

- Base and site clearance will be required for Battelle's site employees. We will furnish you with personal information for each person at least one week prior to starting field operations.

- Regulatory approval, if any is required, will need to be obtained by the base prior to start-up of the bioventing system. The system will likely be configured for air injection so there will be no point source vapor emission from the system. The wells to be installed will not intersect the apparent water table and no groundwater will be pumped. A letter from the Massachusetts DEP (Attachment 1) presented several concerns with the bioventing test plan. These concerns are addressed below.

Regulatory Issues-

1- **General Approval Requirements-** DEP approval is necessary for the initiation of remediation of petroleum releases. This approval should be pursued by the base for the long-term bioventing test. The soil gas survey, vent well and monitoring point installation, air permeability test, and in situ respiration test are all standard field activities that generally do not require any regulatory approval prior to initiation. Battelle is available to discuss any of these activities with the DEP prior to start up of field activities.

2- **Air Quality Permits and Approvals-** The only air injection planned for this study is the injection of ambient atmospheric air into the vadose zone as a oxygen source for biological activity. Should conditions require the extraction of soil gas (i.e. a basement adjacent to the vent well) then treatment and permitting requirements will be discussed with the DEP.

3- **Groundwater Remediation-** The purpose of this research project is to investigate the efficacy of bioventing for the remediation of petroleum contaminated soils in the vadose zone. While bioventing, as configured for this project, does not directly address groundwater contamination, it has proven to be an effective technology for the remediation of petroleum contaminated soils. These soils typically act as the long-term source of localized groundwater contamination. Removal of the contaminant source is paramount in any groundwater remediation effort.

4- **Nutrient Addition-** Nutrient addition is not currently planned for this site.

5- **Field Screening of Split-Spoon Samples-** The Jar Headspace Technique will be employed for selected samples. Samples will be analyzed for BTEX via EPA Method 8020 and TPH via EPA Method 418.1. Samples will also be analyzed for nutrients.

Please let me know if there are any other regulatory concerns which need to be addressed. If you have any questions please feel free to call me at (614) 424-6122.

Sincerely,

Jeffrey A. Kittel
Researcher
Environmental Technology

JAK:mla

ATTACHMENT 1

Commonwealth of Massachusetts
Executive Office of Environmental Affairs
Department of Environmental Protection
Metro Boston/Northeast Regional Office

William F. Weld
Governor
Daniel S. Greenbaum
Commissioner

JUN 10 1992

Mr. Robert Spelfogel
Hanscom Air Force Base
3245th ABG/DEEV
Bedford, MA 01730

RE: BEDFORD - Hanscom AFB
Bioventing Treatability Test
DEP Case #3-3882

Dear Mr. Spelfogel:

The Department of Environmental Protection is in receipt of a January 1992 "Report, Test Plan And Technical Protocol For A Field Treatability Test For Bioventing". This report was prepared for the U.S. Air Force by Battelle Corporation and was submitted to the Department by the Air Force with a request to provide information concerning the regulatory requirements of the bioventing remediation technique. Preliminary approval of the bioventing concept was also requested. Hanscom Air Force Base is planning to contract Battelle Corporation to conduct Bioventing Treatability Testing at Buildings 1812 and 1639.

Building 1639 (DEP Case #3-3882) is the Air Force Base Service Station. Department files indicate three petroleum release incidents at this location. These releases were assigned the incident response numbers N92-0837, N91-794 and N90-1884. Gasoline, #2 fuel oil, and waste lubricating oil have been released to soil and/or groundwater at this site.

At Building 1812 soil samples collected from borings were found to be contaminated with concentrations of Total Petroleum Hydrocarbons as high as 2830 mg/kg.

The bioventing process uses aeration of subsurface soils to stimulate in-situ biological activity and promote bioremediation. The following points outline the bioventing process.

(1) Forced air is supplied to the contaminated unsaturated zone to produce the aerobic conditions necessary for biodegradation.

(2) Airflow is optimized to reduce volatilization while maintaining aerobic conditions.

(3) Local soil gas conditions are monitored to assure aerobic conditions.

(4) Moisture and nutrients are added to the contaminated unsaturated zone if necessary.

(5) Dewatering is conducted, if necessary to lower the water table below the contaminated soils.

After review of the above mentioned report the Department hereby approves of the initiation of Bioventing Field Treatability Testing at Buildings 1639 and 1812. The following comments are also provided:

* General Approval Requirements.
Departmental approval must be obtained for the initiation of the remediation of releases of petroleum or hazardous materials at Locations To Be Investigated or Confirmed Disposal Sites. A bioventing system to remediate petroleum or hazardous materials releases at Hanscom Air Force Base is subject to the above-mentioned approvals.

* Air Quality Permits and Approvals.
Page 5 Section 2.1.3 states that when air is injected into a contaminated zone and withdrawn from clean soils volatile hydrocarbons are allowed to degrade prior to being withdrawn thereby eliminating contaminated off-gases. "This configuration typically does not require air emission permitting".

Be advised that all air emissions resulting from treatment systems at petroleum or hazardous materials disposal sites are subject to the Air Pollution Control Regulations at 310 CMR 6.00-8.00 in addition to the requirements of the Massachusetts Contingency Plan at 310 CMR 40.000.

In general, if an air contaminant source emits less than one ton of contaminants per year, then that emission source is not subject to application for approval from the Department of Environmental Protection's Division of Air Quality.

Whether or not the emission source emits more than one ton of pollutants per year, if the emission is part of a system being operated to remediate a release of petroleum or hazardous materials to the environment, then that system is subject to M.G.L. c.21E and the MCP. The DEP Bureau Of Waste Site Cleanup requires that off-gas controls be installed on all point source remedial air emissions where Soil Vapor Extraction systems are utilized. Off-gas controls must be implemented during the first 180 days of operation at a minimum. Off-gas treatment must reduce vapor-phase emissions of VOC's by at least 95 percent. Approval to operate without emission controls after the first 180 days are contingent upon receipt of information confirming the absence of a threat of harm to human health or the environment.

* Page 5 indicates that during a 1988 study at Hill Air Force Base it became apparent that bioventing had great potential for remediating JP-4 fuel-contaminated soils.

It is not clear however that bioventing is effective for remediation of groundwater contaminated with fuel oils. Many of the components contained in aircraft fuels, diesel fuel and heavier petroleum fuel products are not significantly volatile and would not readily be transferred from the groundwater to the unsaturated zone where they could be treated by the bioventing system. In order to achieve a permanent solution to the petroleum contamination present at a site it may be necessary to reduce the levels of contaminants in soil and groundwater to levels which do not pose a significant or otherwise unacceptable risk to public health, safety, public welfare or the environment.

* Page 6 indicates that adding nutrients as required to increase biodegradation rates may be necessary. The addition of nutrients to the subsurface is subject to the requirements of M.G.L. c.21 and the Groundwater Discharge Permit Regulations (314 CMR 5.00). Nutrient addition may be initiated only upon receipt of a Groundwater Discharge Permit issued by the DEP Division of Groundwater Pollution Control.

* Page 42, Section 2.1.2 - Exploratory Boring in Deep Soils, states that "Split-spoon samples will be visually checked for fuel contamination and screened for volatile emissions by passing a hydrocarbon analyzer slowly over the open split-spoon".

This method is not acceptable for the field screening of split spoon samples for petroleum hydrocarbon contamination. The Jar Headspace Technique (Reference: "Management Procedures for Excavated Soils Contaminated with Virgin Petroleum Oils", Policy #WSC-89-001) should be applied for the measurement of volatile petroleum constituents. Total Petroleum Hydrocarbons by Infrared (Standard Methods 503 or 5520) or Oil Fingerprinting (ASTM D 3328) should be used to determine concentrations of non-volatile petroleum hydrocarbons.

If you have any questions regarding this matter please do not hesitate to contact Jack Miano at the letterhead address or telephone (617) 935-2160 X142.

Very truly yours,

Jack Miano
Environmental Engineer

Stephen M. Johnson
Acting Chief,
Site Management Branch

SMJ/JM/ae

cc: DEP, BWSC, Boston, Attn: Jeff Krukonis
DEP, DWS, NERO, Attn: Jim Persky
Bedford BOH, Attn: David Black
Bedford DPW, 312 Great Rd., Bedford, MA 01730,
Attn: Mr. Richard Warrington, Director

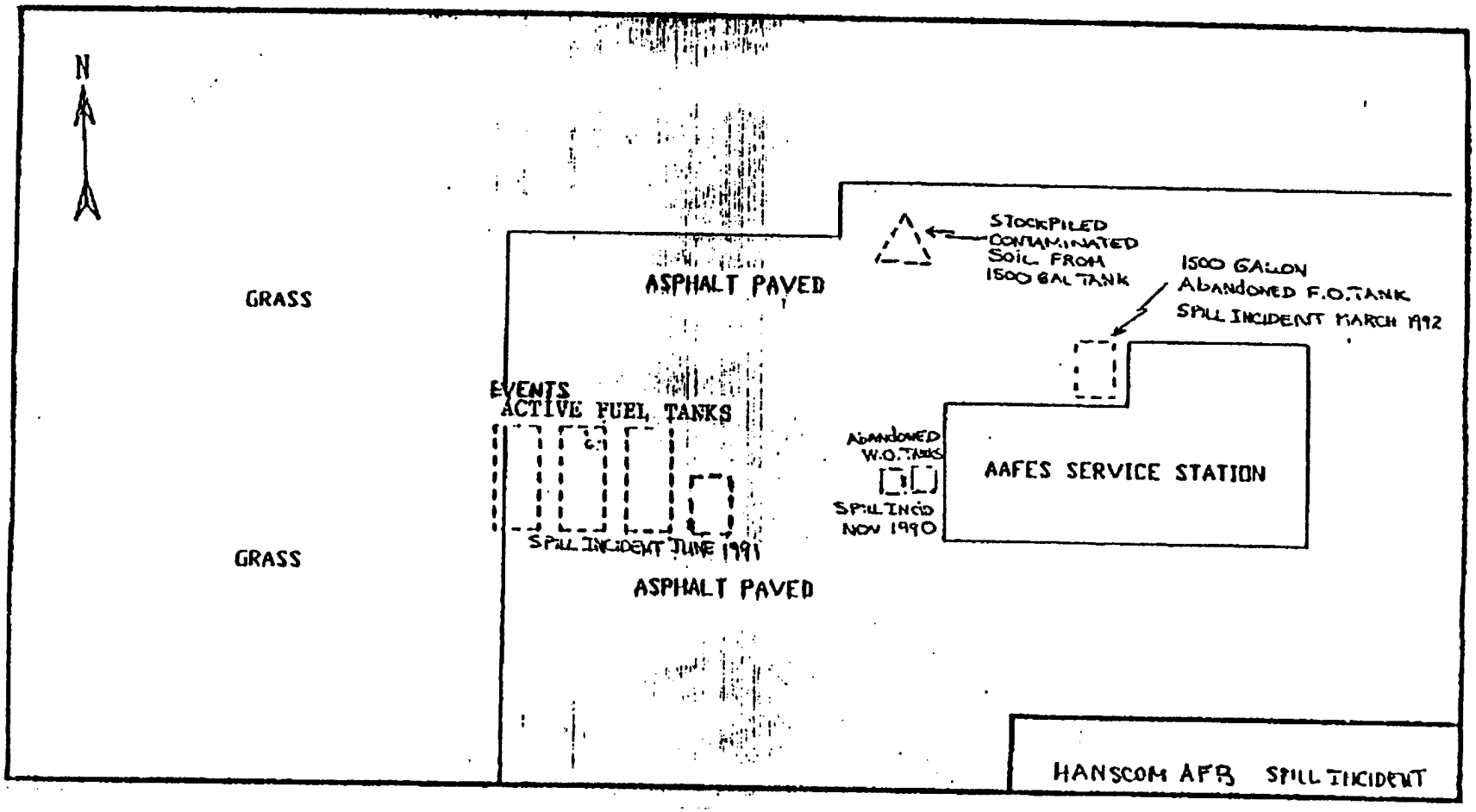


FIGURE 1. SITE DIAGRAM FOR BUILDING 1639

FORMER LOCATION OF UNDERGROUND STORAGE TANK
BUILDING NO. 1816
HANSCOM AIR FORCE BASE, MASSACHUSETTS

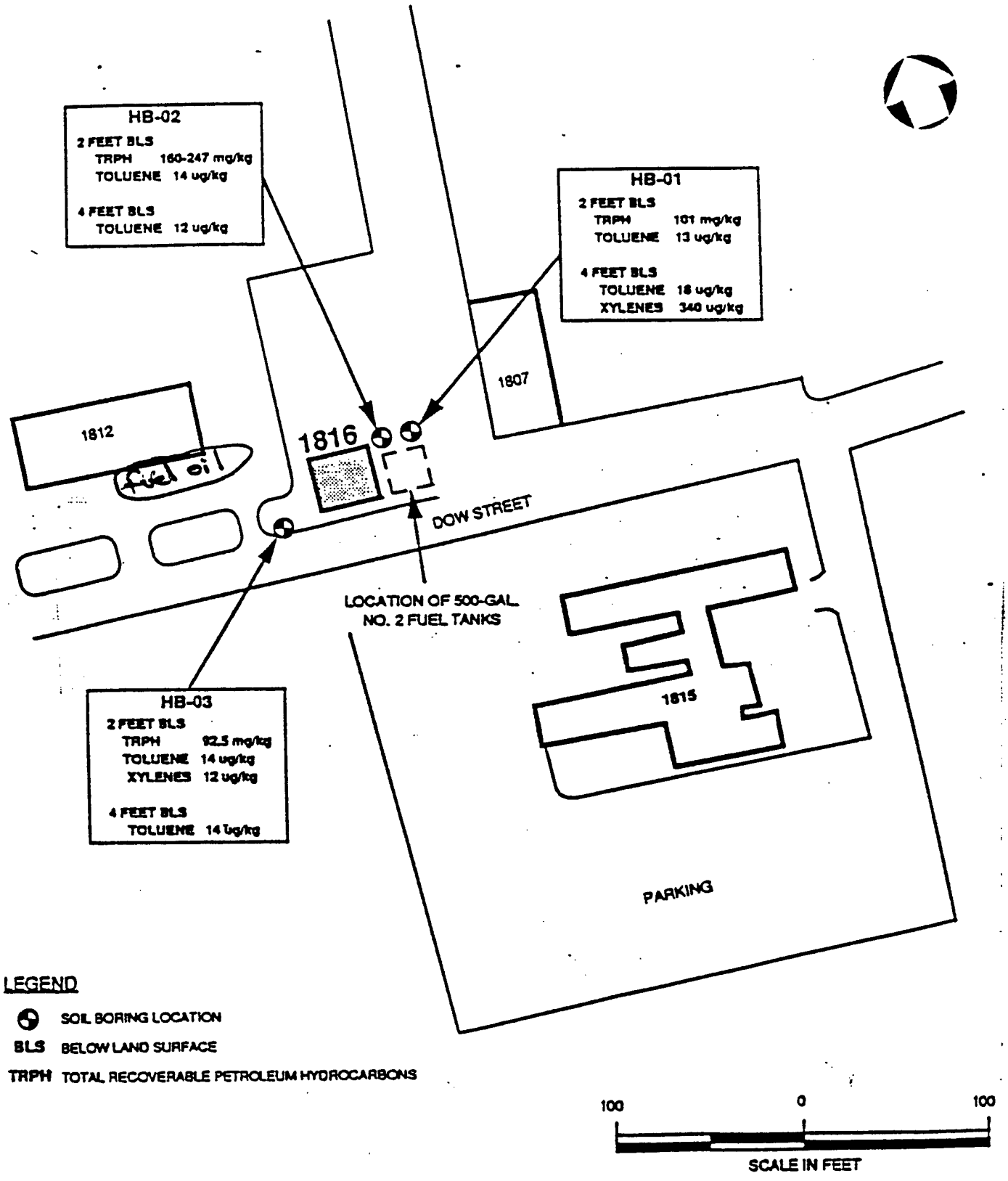


FIGURE 2. SITE DIAGRAM FOR BUILDING 1812

GENERALIZED GEOLOGIC AND HYDROGEOLOGIC COLUMN
INVESTIGATION OF SUSPECTED HAZARDOUS WASTE SITES
HANSCOM AIR FORCE BASE, MASSACHUSETTS

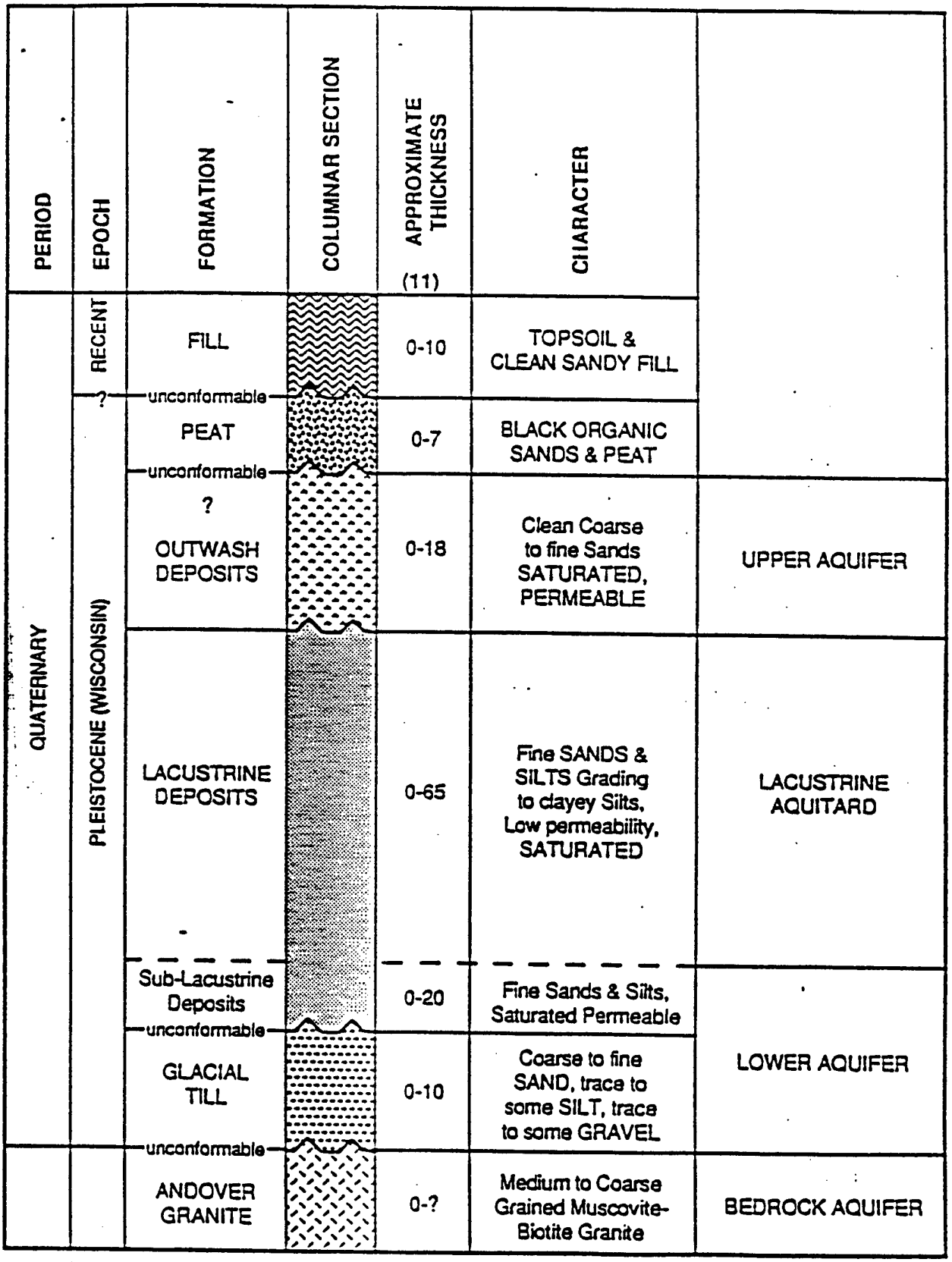


FIGURE 3. GENERALIZED GEOLOGIC AND HYDROGEOLOGIC COLUMN FOR HANSCOM AFB, MA.

BORING NUMBER	HB-19
JOB NUMBER	11-9540
DATE STARTED	4-24-90
DATE COMPLETED	4-24-90
DRILLED BY	TN
LOGGED BY	KMP
CHECKED BY	GPM

REMARKS:

PAGE 1 OF 1

FLUSH MOUNTED WELL
SWL MEASURED 9.34' BELOW TOC ON 5/29/90
WELL ALIGNMENT TEST COMPLETED 5/18/90
HNU READINGS RECORDED IN "LAB TEST" COLUMN

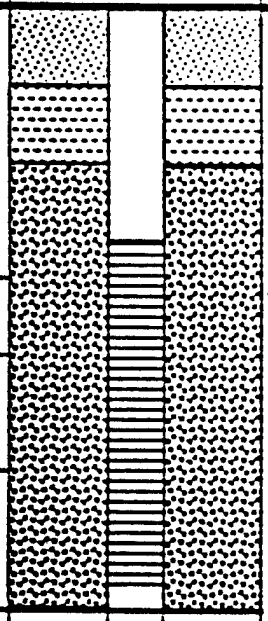
ELEV. IN FEET	DEPTH IN FEET	DESCRIPTION	MONITORING WELL CONSTRUCTION	SYM-BOLS	LAB TESTS	SPT N VALUE
129.02	0.0	Firm yellowish brown (10 YR 5/6) to very pale brown (10 YR 7/3) fine to medium grained SAND (SP)			0	19
					0	22
122.02	7.0	Firm light brownish gray (2.5 YR 6/2) fine grained SAND (SP)			0	17
120.02	9.0	Very stiff light yellowish brown (2.5 Y 6/4) SILT (ML)			0	16
117.02	12.0	Very stiff light yellowish brown (2.5 Y 6/4) SILT with lenses of fine grained sand (ML)			0	17
113.52	15.5	Boring Terminated at 15.5'				16

FIGURE 4. TEST BORING RECORD FOR SOIL BORING IN THE VICINITY OF BUILDING 1812

BORING NUMBER	HB-03
JOB NUMBER	11-9540
DATE STARTED	5-1-90
DATE COMPLETED	5-1-90
DRILLED BY	TN
LOGGED BY	KMP
CHECKED BY	GPM

REMARKS:

PAGE 1 OF 1

FLUSH MOUNTED WELL
SWL MEASURED 3.05' BELOW TOC ON 5/29/90
WELL ALIGNMENT TEST COMPLETED 5/18/90
HNU READINGS RECORDED IN "LAB TEST" COLUMN

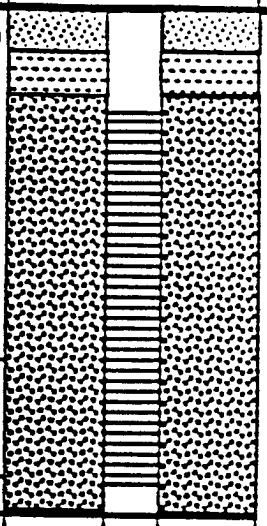
ELEV. IN FEET	DEPTH IN FEET	DESCRIPTION	MONITORING WELL CONSTRUCTION	SYM-BOLS	LAB TESTS	SPT N VALUE
132.00	0.0	Very stiff to hard light olive brown (2.5 Y 5/4) SILT (ML)			0	32
					0	20
					0	27
123.00	9.0	Firm yellowish brown (10 YR 5/6) fine to medium grained SAND with stratifications (SM)			0	17
120.00	12.0	Very stiff grayish brown (2.5 Y 5/2) clayey SILT (ML)			0	31
	13.0	Boring Terminated at 12.0'				

FIGURE 5. TEST BORING RECORD FOR SOIL BORING IN THE VICINITY OF BUILDING 1812

APPENDIX B

ANALYTICAL REPORT FOR BUILDING 1639, BUILDING 1812, AND BACKGROUND AREA

@ AIR TOXICS LTD.

AN ENVIRONMENTAL ANALYTICAL LABORATORY

WORK ORDER #: 9210075

Work Order Summary

CLIENT:	Mr. Jeff Kittel Battelle 505 King Ave. Columbus, OH 43201	**BILL TO:**	Accounts Payable Engineering Science 1700 Broadway Ste. 900 Denver, CO 80290
PHONE:	614-424-6122		**INVOICE #** 8630
FAX:	614-424-3667		**P.O. #** DE268.03.04
DATE RECEIVED:		10/14/92	**AMOUNT:** $910.00
DATE REPORTED:		10/26/92	**PROJECT #** G4468-0640

FRACTION #	NAME	TEST	Receipt VAC./Press.	PRICE
01A	H1-A-2.5	TO-3	0 "Hg	$120.00
02A	H1-A-5	TO-3	0 "Hg	$120.00
03A	H1-B-2.5	TO-3	2.0 "Hg	$120.00
04A	H1-B-5	TO-3	1.0 "Hg	$120.00
05A	H1-C-3.5	TO-3	0.5 "Hg	$120.00
06A	H1-C-6	TO-3	0.5 "Hg	$120.00
07A	H1-BG-1.5-9	TO-3	1.0 "Hg	$120.00
07B	H1-BG-1.5-9 Duplicate	TO-3	1.0 "Hg	NC
08A	Method Spike	TO-3	NA	NC
09A	Lab Blank	TO-3	NA	NC

Misc Charges	1 Liter SUMMA Canister Preparation (7) @ $10.00 each.	$70.00

CERTIFIED BY: Arnold L. Freeman DATE: 10/26/92

Laboratory Director

11325 SUNRISE GOLD CIRCLE, SUITE E • RANCHO CORDOVA, CA 95742
(916) 638-9892 • FAX (916) 638-9917

AIR TOXICS LTD.

SAMPLE NAME: H1-A-2.5
ID#: 9210075-01A

EPA Method TO-3
(Aromatic Volatile Organics in Air)

BTXE BY GC/PID

File Name:	6101508	Date of Collection: 10/12/92
Dil. Factor:	200	Date of Analysis: 10/15/92

Compound	MDL (ppmv)	MDL (uG/L)	Amount (ppmv)	Amount (uG/L)
Benzene	0.20	0.62	5.2	16
Toluene	0.20	0.74	4.2	15
Total Xylenes	0.20	0.85	2.9	12
Ethyl Benzene	0.20	0.85	1.1	4.7

TOTAL PETROLEUM HYDROCARBONS
GC/FID
(Quantitated as Jet Fuel)

File Name:	6101508	Date of Collection: 10/12/92
Dil. Factor:	200	Date of Analysis: 10/15/92

Compound	MDL (ppmv)	MDL (uG/L)	Amount (ppmv)	Amount (uG/L)
TPH*	2.0	8.0	5600	22000

*TPH referenced to Jet Fuel (MW=156)

AIR TOXICS LTD.

SAMPLE NAME: H1-A-5
ID#: 9210075-02A

EPA Method TO-3
(Aromatic Volatile Organics in Air)

BTXE BY GC/PID

File Name:	6101509	Date of Collection: 10/12/92
Dil. Factor:	500	Date of Analysis: 10/15/92

Compound	MDL (ppmv)	MDL (uG/L)	Amount (ppmv)	Amount (uG/L)
Benzene	0.50	1.6	27	84
Toluene	0.50	1.8	35	130
Total Xylenes	0.50	2.1	30	130
Ethyl Benzene	0.50	2.1	10	42

TOTAL PETROLEUM HYDROCARBONS
GC/FID
(Quantitated as Jet Fuel)

File Name:	6101509	Date of Collection: 10/12/92
Dil. Factor:	500	Date of Analysis: 10/15/92

Compound	MDL (ppmv)	MDL (uG/L)	Amount (ppmv)	Amount (uG/L)
TPH*	5.0	20	19000	76000

*TPH referenced to Jet Fuel (MW=156)

AIR TOXICS LTD.

SAMPLE NAME: H1-B-2.5
ID#: 9210075-03A

EPA Method TO-3
(Aromatic Volatile Organics in Air)

BTXE BY GC/PID

File Name:	6101510	Date of Collection: 10/12/92	
Dil. Factor:	220	Date of Analysis: 10/15/92	
Compound	MDL (ppmv)	MDL (uG/L)	Amount (ppmv)	Amount (uG/L)
Benzene	0.22	0.69	2.8	8.7
Toluene	0.22	0.81	1.3	4.8
Total Xylenes	0.22	0.93	1.9	8.1
Ethyl Benzene	0.22	0.93	0.84	3.6

TOTAL PETROLEUM HYDROCARBONS
GC/FID
(Quantitated as Jet Fuel)

File Name:	6101510	Date of Collection: 10/12/92	
Dil. Factor:	220	Date of Analysis: 10/15/92	
Compound	MDL (ppmv)	MDL (uG/L)	Amount (ppmv)	Amount (uG/L)
TPH*	2.2	8.8	2700	11000

*TPH referenced to Jet Fuel (MW=156)

AIR TOXICS LTD.

SAMPLE NAME: H1-B-5
ID#: 9210075-04A

EPA Method TO-3
(Aromatic Volatile Organics in Air)

BTXE BY GC/PID

File Name:	6101606	Date of Collection: 10/12/92	
Dil. Factor:	210	Date of Analysis: 10/16/92	
Compound	MDL (ppmv)	MDL (uG/L)	Amount (ppmv)	Amount (uG/L)
Benzene	0.21	0.66	2.4	7.5
Toluene	0.21	0.77	0.84	3.1
Total Xylenes	0.21	0.89	1.5	6.4
Ethyl Benzene	0.21	0.89	0.42	1.8

TOTAL PETROLEUM HYDROCARBONS
GC/FID
(Quantitated as Jet Fuel)

File Name:	6101606	Date of Collection: 10/12/92	
Dil. Factor:	210	Date of Analysis: 10/16/92	
Compound	MDL (ppmv)	MDL (uG/L)	Amount (ppmv)	Amount (uG/L)
TPH*	2.1	8.4	3200	13000

*TPH referenced to Jet Fuel (MW=156)

AIR TOXICS LTD.

SAMPLE NAME: H1-C-3.5
ID#: 9210075-05A

EPA Method TO-3
(Aromatic Volatile Organics in Air)

BTXE BY GC/PID

File Name:	6101607	Date of Collection: 10/12/92	
Dil. Factor:	10	Date of Analysis: 10/16/92	
Compound	MDL (ppmv)	MDL (uG/L)	Amount (ppmv)	Amount (uG/L)
Benzene	0.010	0.031	0.44	1.4
Toluene	0.010	0.037	0.13	0.48
Total Xylenes	0.010	0.042	0.37	1.6
Ethyl Benzene	0.010	0.042	0.11	0.47

TOTAL PETROLEUM HYDROCARBONS
GC/FID
(Quantitated as Jet Fuel)

File Name:	6101607	Date of Collection: 10/12/92	
Dil. Factor:	10	Date of Analysis: 10/16/92	
Compound	MDL (ppmv)	MDL (uG/L)	Amount (ppmv)	Amount (uG/L)
TPH*	0.10	0.40	280	1100

*TPH referenced to Jet Fuel (MW=156)

AIR TOXICS LTD.

SAMPLE NAME: H1-C-6
ID#: 9210075-06A

EPA Method TO-3
(Aromatic Volatile Organics in Air)

BTXE BY GC/PID

File Name:	6101514	Date of Collection: 10/12/92
Dil. Factor:	2100	Date of Analysis: 10/15/92

Compound	MDL (ppmv)	MDL (uG/L)	Amount (ppmv)	Amount (uG/L)
Benzene	2.1	6.6	11	34
Toluene	2.1	7.7	20	74
Total Xylenes	2.1	8.9	67	280
Ethyl Benzene	2.1	8.9	9.3	39

TOTAL PETROLEUM HYDROCARBONS
GC/FID
(Quantitated as Jet Fuel)

File Name:	6101514	Date of Collection: 10/12/92
Dil. Factor:	2100	Date of Analysis: 10/15/92

Compound	MDL (ppmv)	MDL (uG/L)	Amount (ppmv)	Amount (uG/L)
TPH*	21	84	11000	44000

*TPH referenced to Jet Fuel (MW=156)

AIR TOXICS LTD.

SAMPLE NAME: H1-BG-1.5-9
ID#: 9210075-07A

EPA Method TO-3
(Aromatic Volatile Organics in Air)

BTXE BY GC/PID

File Name:	6101604	Date of Collection: 10/12/92
Dil. Factor:	10	Date of Analysis: 10/16/92

Compound	MDL (ppmv)	MDL (uG/L)	Amount (ppmv)	Amount (uG/L)
Benzene	0.010	0.031	0.16	0.50
Toluene	0.010	0.037	0.93	3.4
Total Xylenes	0.010	0.042	4.7	20
Ethyl Benzene	0.010	0.042	0.43	1.8

TOTAL PETROLEUM HYDROCARBONS
GC/FID
(Quantitated as Jet Fuel)

File Name:	6101604	Date of Collection: 10/12/92
Dil. Factor:	10	Date of Analysis: 10/16/92

Compound	MDL (ppmv)	MDL (uG/L)	Amount (ppmv)	Amount (uG/L)
TPH*	0.10	0.40	330	1300

*TPH referenced to Jet Fuel (MW=156)

AIR TOXICS LTD.

SAMPLE NAME: H1-BG-1.5-9 Duplicate
ID#: 9210075-07B

EPA Method TO-3
(Aromatic Volatile Organics in Air)

BTXE BY GC/PID

File Name:	6101605	Date of Collection: 10/12/92
Dil. Factor:	10	Date of Analysis: 10/16/92

Compound	MDL (ppmv)	MDL (uG/L)	Amount (ppmv)	Amount (uG/L)
Benzene	0.010	0.031	0.16	0.50
Toluene	0.010	0.037	0.93	3.4
Total Xylenes	0.010	0.042	4.7	20
Ethyl Benzene	0.010	0.042	0.43	1.8

TOTAL PETROLEUM HYDROCARBONS
GC/FID
(Quantitated as Jet Fuel)

File Name:	6101605	Date of Collection: 10/12/92
Dil. Factor:	10	Date of Analysis: 10/16/92

Compound	MDL (ppmv)	MDL (uG/L)	Amount (ppmv)	Amount (uG/L)
TPH*	0.10	0.40	340	1400

*TPH referenced to Jet Fuel (MW=156)

AIR TOXICS LTD.

SAMPLE NAME: Method Spike
ID#: 9210075-08A

EPA Method TO-3
(Aromatic Volatile Organics in Air)

BTXE BY GC/PID

File Name:	**6101602**		**Date of Collection: 10/12/92**
Dil. Factor:	**1.0**		**Date of Analysis: 10/16/92**
Compound	**MDL (ppmv)**	**MDL (uG/L)**	**% Recovery**
Benzene	0.001	0.003	90
Toluene	0.001	0.004	83
Total Xylenes	0.001	0.004	80
Ethyl Benzene	0.001	0.004	80

TOTAL PETROLEUM HYDROCARBONS
GC/FID
(Quantitated as Jet Fuel)

File Name:	**6101603**		**Date of Collection: 10/12/92**
Dil. Factor:	**1.0**		**Date of Analysis: 10/16/92**
Compound	**MDL (ppmv)**	**MDL (uG/L)**	**% Recovery**
TPH*	0.010	0.040	110

*TPH referenced to Jet Fuel (MW=156)

AIR TOXICS LTD.

SAMPLE NAME: Lab Blank
ID#: 9210075-09A

EPA Method TO-3
(Aromatic Volatile Organics in Air)

BTXE BY GC/PID

File Name:	6101501	Date of Collection:	10/12/92
Dil. Factor:	1.0	Date of Analysis:	10/15/92

Compound	MDL (ppmv)	MDL (uG/L)	Amount (ppmv)	Amount (uG/L)
Benzene	0.001	0.003	Not Detected	Not Detected
Toluene	0.001	0.004	Not Detected	Not Detected
Total Xylenes	0.001	0.004	Not Detected	Not Detected
Ethyl Benzene	0.001	0.004	Not Detected	Not Detected

TOTAL PETROLEUM HYDROCARBONS
GC/FID
(Quantitated as Jet Fuel)

File Name:	6101501	Date of Collection:	10/12/92
Dil. Factor:	1.0	Date of Analysis:	10/15/92

Compound	MDL (ppmv)	MDL (uG/L)	Amount (ppmv)	Amount (uG/L)
TPH*	0.010	0.040	Not Detected	Not Detected

*TPH referenced to Jet Fuel (MW=156)

@ AIR TOXICS LTD.
AN ENVIRONMENTAL ANALYTICAL LABORATORY

11325 SUNRISE GOLD CIRCLE, SUITE 'E'
RANCHO CORDOVA, CA 95742
(916) 638-9892 • FAX (916) 638-9917

CHAIN OF CUSTODY RECORD

Page ____ of ____

PROJECT # G4468-0640 PO # _____ COLLECTED BY (Signature) MAT / JA

REMARKS _____

FIELD SAMPLE I.D.#	SAMPLING MEDIA (Tenax, Canister etc.)	DATE/TIME	ANALYSIS	VAC./PRESSURE	LAB I.D. #
HI-A-2.5	Canister	12 Oct / 0900	BTEX / TVH	0" Hg	
HI-A-5	"	"	"	0" Hg	
HI-B-2.5	"	"	"	2.0" Hg	
HI-B-5	"	"	"	1" Hg	
HI-C-3.5	"	"	"	0.5" Hg	
HI-C-6	"	"	"	0.5" Hg	
HI-BG-7.5	"	"	"	1" Hg	

RELINQUISHED BY: DATE/TIME	RECEIVED BY: DATE/TIME	RELINQUISHED BY: DATE/TIME	RECEIVED BY: DATE/TIME
James E. Abbott 10/13/92 11:20 AM	Alys Meuplatt 10/14/92 0915		

LAB USE ONLY

SHIPPER NAME	AIR BILL #	OPENED BY: DATE/TIME	TEMP(°C)	CONDITION

REMARKS _____

ENGINEERING-SCIENCE, INC.

BERKELEY LABORATORY
600 BANCROFT WAY
BERKELEY, CA 94710
Tel: (415) 841-7353

Report Date: November 19, 1992

Work Order No.:4432

Client: Doug Downey
ES Denver/AFCEE/Hanscom AFB
1700 Broadway
Denver, CO 80290

Date of Sample Receipt: 10/06/92

Your soil samples identified as:

H1-VW-4'-4.5'
H1-VW-4.5'-5.0'
H1-A-3'-4'
H2-VW-3'-3.5'
H2-VW-4'-4.5'
H1-BKG-2.5'-3'

were analyzed for BTEX by EPA Method 8020, TRPH by EPA Method 418.1, TKN, total phosphorus, soil classification, pH, alkalinity, iron and moisture.

The analytical reports for the samples listed above are attached.

GC VOLATILES DATA PACKAGE

VOLATILE ORGANICS CASE NARRATIVE
WORK ORDER NO. 4432
EPA METHOD 8020

11/19/92

Sample H1-VW-S3-3.5' (4432-04) was run as a medium level due to the presence of high concentrations of non-target analytes.

Berkeley,CA 94710

GC ANALYTICAL REPORT

Analytical Method

BTEX Aromatic Compounds

Work Order NO.:4452 % Moisture: 22.2

Client ID:HI-VW-4'-4.5' Matrix:SOIL

Laboratory ID:4452-1 Level:LOW

Date Collected: 10/02/92 Unit:UG/KG

Dilution Factor: 1 Date Analyzed:10/15/92

Date Confirmed:NA

Compound	Result		Reporting Limit
Benzene	48.0	D=5	0.8
Ethyl Benzene	17.0		0.8
Toluene	20.0		0.9
Xylenes (total)	20.0		1.2

ND-Not Detected
NA-Not Applicable
D-Dilution Factor

ANALYST: AB

GROUP LEADER:

GC ANALYTICAL REPORT
Analytical Method
BTEX Aromatic Compounds

Work Order NO.:4432 % Moisture: 21.81

Client ID:HI-VW-4.5'-5.0' Matrix:SOIL

Laboratory ID:4432-2 Level:MEDIUM

Date Collected: 10/02/92 Unit:UG/KG

Dilution Factor: 1 Date Analyzed:10/14/92
Date Confirmed:NA

Compound	Result	Reporting Limit
Benzene	670.0	77.0
Ethyl Benzene	450.0	64.0
Toluene	270.0	90.0
Xylenes (total)	450.0	120.0

ND-Not Detected
NA-Not Applicable
D-Dilution Factor

ANALYST: AB

GROUP LEADER: [signature]

ES-ENGINEERING SCIENCE, INC.
800 Bancroft Way
Berkeley,CA 94710

GC ANALYTICAL REPORT
Analytical Method
BTEX Aromatic Compounds

Work Order NO.:4432 % Moisture: 5.81

Client ID:HI-A-3'-4' Matrix:SOIL

Laboratory ID:4432-3 Level:MEDIUM

Date Collected: 10/02/92 Unit:UG/KG

Dilution Factor: 2 Date Analyzed:10/14/92
Date Confirmed:NA

Compound	Result	Reporting Limit
Benzene	1000.0	130.0
Ethyl Benzene	1300.0	110.0
Toluene	4900.0	150.0
Xylenes (total)	12000.0	190.0

ND-Not Detected
NA-Not Applicable
D-Dilution Factor

ANALYST: HB GROUP LEADER: [signature]

ES-ENGINEERING SCIENCE, INC.
600 Bancroft Way
Berkeley,CA 94710

GC ANALYTICAL REPORT
Analytical Method
BTEX Aromatic Compounds

Work Order NO.:4432 TP 11/18/92 % Moisture: 3.2

Client ID:HF-VW-3'-3.5' Matrix:SOIL

Laboratory ID:4432-4 Level:MEDIUM

Date Collected: 10/03/92 Unit:UG/KG

Dilution Factor: 1 Date Analyzed:10/14/92
Date Confirmed:NA

Compound	Result	Reporting Limit
Benzene	ND	62.0
Ethyl Benzene	ND	52.0
Toluene	ND	72.0
Xylenes (total)	ND	93.0

ND-Not Detected
NA-Not Applicable
D-Dilution Factor

ANALYST: AB GROUP LEADER:

Berkeley,CA 94710

GC ANALYTICAL REPORT
Analytical Method
BTEX Aromatic Compounds

Work Order NO.:4452 TP 11/18/92 % Moisture: 6.14

Client ID:H2-VW-4'-4.5' Matrix:SOIL

Laboratory ID:4452-5 Level:LOW

Date Collected: 10/05/92 Unit:UG/KG

Dilution Factor: 5 Date Analyzed:10/15/92
Date Confirmed:NA

Compound	Result	Reporting Limit
Benzene	ND	5.2
Ethyl Benzene	ND	2.6
Toluene	15.0	3.7
Xylenes (total)	51.0	4.8

ND-Not Detected
NA-Not Applicable
D-Dilution Factor

ANALYST: AB GROUP LEADER: Richard

LS-ENGINEERING SCIENCE, INC.
Berkeley,CA 94710

GC ANALYTICAL REPORT
Analytical Method
BTEX Aromatic Compounds

Work Order NO.:4432 % Moisture:NA

Client ID:HI-BKG-2.5'-3' Matrix:SOIL

Laboratory ID:4432-7 Level:LOW

Date Collected: 10/04/92 Unit:UG/KG

Dilution Factor: 1 Date Analyzed:10/13/92
Date Confirmed:NA

Compound	Result	Reporting Limit
Benzene	ND	0.6
Ethyl Benzene	ND	0.5
Toluene	ND	0.7
Xylenes (total)	ND	0.9

ND-Not Detected
NA-Not Applicable
D-Dilution Factor

ANALYST: AB

GROUP LEADER: [signature]

EA ENGINEERING SCIENCE, INC.
600 Bancroft Way
Berkeley,CA 94710

GC ANALYTICAL REPORT
Analytical Method
BTEX Aromatic Compounds

Work Order NO.:4432 % Moisture:NA

Client ID:METHOD BLANK Matrix:SOIL

Laboratory ID:MSVG4921015 Level:LOW

Date Collected: NA Unit:UG/KG

Dilution Factor: 1 Date Analyzed:10/15/92
Date Confirmed:NA

Compound	Result	Reporting Limit
Benzene	ND	0.6
Ethyl Benzene	ND	0.5
Toluene	ND	0.7
Xylenes (total)	ND	0.9

ND-Not Detected
NA-Not Applicable
D-Dilution Factor

ANALYST: AB

GROUP LEADER: [signature]

ES-ENGINEERING SCIENCE, INC.
600 Bancroft Way
Berkeley,CA 94710

GC ANALYTICAL REPORT
Analytical Method
BTEX Aromatic Compounds

Work Order NO.:4432 % Moisture:NA

Client ID:METHOD BLANK Matrix:SOIL

Laboratory ID:MWVG4921014 Level:MEDIUM

Date Collected: NA Unit:UG/KG

Dilution Factor: 1 Date Analyzed:10/14/92
Date Confirmed:NA

Compound	Result	Reporting Limit
Benzene	ND	60.0
Ethyl Benzene	ND	50.0
Toluene	ND	70.0
Xylenes (total)	ND	90.0

ND-Not Detected
NA-Not Applicable
D-Dilution Factor

ANALYST:AS GROUP LEADER:

ENVIRONMENTAL SCIENCE, INC.
2000 Dwight Way
Berkeley,CA 94710

GC ANALYTICAL REPORT
Analytical Method
BTEX Aromatic Compounds

Work Order NO.:4432 % Moisture:NA

Client ID:METHOD BLANK Matrix:SOIL

Laboratory ID:MSVG4921015 Level:LOW

Date Collected: NA Unit:UG/KG

Dilution Factor: 1 Date Analyzed:10/15/92
Date Confirmed:NA

Compound	Result	Reporting Limit
Benzene	ND	0.6
Ethyl Benzene	ND	0.5
Toluene	ND	0.7
Xylenes (total)	ND	0.9

ND-Not Detected
NA-Not Applicable
D-Dilution Factor

ANALYST: AB

GROUP LEADER:

ES-ENGINEERING SCIENCE, INC.

600 BANCROFT WAY
BERKELEY, CA 94710

GC ANALYTICAL REPORT
ANALYTICAL REPORT
BTEX AROMATIC COMPOUNDS

MATRIX: SOIL

DATE: 10/14/92

LABORATORY NO.	CLIENT ID	a-a-a-TriFluoro Toluene
MWUG4921014	METHOD BLANK	91
4432-2	HI-VW-4.5'-5.0'	82
4432-3	HI-A-3'-4'	113
4432-4	HI-VW-3'-3.5'	122

TP 11/18

ES-ENGINEERING SCIENCE,INC.
600 BANCROFT WAY
BERKELEY, CA 94710

GC ANALYTICAL REPORT
ANALYTICAL REPORT
BTEX AROMATIC COMPOUNDS

MATRIX: SOIL

DATE:10/13&15/92

LABORATORY NO.	CLIENT ID	a-a-a-TriFluoro Toluene
MSVG4921013	METHOD BLANK	94
4432-7	HI-BKG-2.5'-3'	114
4435-1	KAFB66-SB1-SS3-5-5.5'	108
MSVG4921015	METHOD BLANK	79
4432-1	HI-VW-4'-4.5'	118
4432-1DIL	HI-VW-4'-4.5'DIL	104
4432-5	HI-VW-4'-4.5'	70
4451-1	MC-VW-7	109

TP 11/18

ES-ENGINEERING SCIENCE, INC.
600 Bancroft Way
Berkeley, CA 94710

QUALITY CONTROL RESULTS SUMMARY
ANALYTICAL REPORT
BTEX AROMATIC COMPOUNDS

Work Order No.: 4432,4451,4455

QC sample No.: SSVG4921009A&B Date analyzed: 10/09/92

Matrix: SOIL Dilution factor: 1

COMPOUND 8010 analysis	SA UG/KG	SR UG/KG	MS UG/KG	MS PR	MSD UG/KG	MSD PR	RPD	QC LIMITS RPD	QC LIMITS PR
COMPOUND 8020 analysis	SA UG/KG	SR UG/KG	MS UG/KG	MS PR	MSD UG/KG	MSD PR	RPD	QC LIMITS RPD	QC LIMITS PR
Benzene	20	ND	22.6	113	23.5	118	4	29	39-150
Toluene	20	ND	21.4	107	22.2	111	4	28	46-148

MS = Spike sample
MSD = Spike sample duplicate
SR = Sample result
SA = Spike added
ND = Not Found At or Above Detection Limits

NC = Not calculated
NA = Not Applicable
** = Out of limits

RPD = 100 x (MS-MSD)/((MS+MSD)/2)

PR = 100 x ((MS or MSD) - SR)/SA

ANALYST: AB QC: MW

ES-ENGINEERING SCIENCE, INC.
600 Bancroft Way
Berkeley, CA 94710

QUALITY CONTROL RESULTS SUMMARY
ANALYTICAL REPORT
BTEX AROMATIC COMPOUNDS

Work Order No.: 4432,4451,4435

QC sample No.: SWUG4921016A&B Date analyzed:10/16/92

Matrix: SOIL Dilution factor:1

COMPOUND				MS		MSD		QC LIMITS	
8010 analysis	SA UG/KG	SR UG/KG	MS UG/KG	PR	MSD UG/KG	PR	RPD	RPD	PR
COMPOUND				**MS**		**MSD**		**QC LIMITS**	
8020 analysis	SA UG/KG	SR UG/KG	MS UG/KG	PR	MSD UG/KG	PR	RPD	RPD	PR
Benzene	2000	ND	2000	100	1640	82	20	29	39-150
Toluene	2000	ND	2600	130	2700	135	4	28	46-148

MS = Spike sample
MSD = Spike sample duplicate
SR = Sample result
SA = Spike added
ND = Not Found At or Above Detection Limits

NC = Not calculated
NA = Not Applicable
** = Out of limits

RPD = 100 x (MS-MSD)/((MS+MSD)/2)

PR = 100 x ((MS or MSD) - SR)/SA

ANALYST: AH QC: RWB

METHOD BLANK SUMMARY

WO # 4432,4451,4435

LAB NAME : ENGINEERING-SCIENCE, INC. DATE ANALYZED 10/13&15/92

LAB SAMPLE ID:MSVG4921013&15 DATE EXTRACTED : NA

MATRIX :LOW SOIL INSTRUMENT ID:VGC-4

LAB SAMPLE ID	CLIENT SAMPLE ID	DATE ANALYZED
MSVG4921013	METHOD BLANK	10/13/92
4432-7	HI-BKG-2.5'-3'	10/13/92
4435-1	KAFB66-SB1-SS3-5-5.5'	10/13/92
MSVG492101~~3~~15	METHOD BLANK	10/15/92
4432-1	HI-VW-4'-4.5'	10/15/92
4432-1DIL	HI-VW-4'-4.5'DIL	10/15/92
4432-5	HI-VW-4'-4.5'	10/15/92
4451-1	MC-VW-7	10/15/92

TP 11/18

METHOD BLANK SUMMARY

WU # 4432

LAB NAME : ENGINEERING-SCIENCE, INC. DATE ANALYZED :10/14/92

LAB SAMPLE ID:MWVG4921014 DATE EXTRACTED : NA

MATRIX :SOIL INSTRUMENT ID:VGC-4

LAB SAMPLE ID	CLIENT SAMPLE ID	DATE ANALYZED
MWVG4921014	METHOD BLANK	10/14/92
4432-2	HI-VW-4.5'-5.0'	10/14/92
4432-3	HI-A-3'-4'	10/14/92
4432-4	HI-VW-3'-3.5'	10/14/92

TD 11/18

TOTAL RECOVERABLE PETROLEUM HYDROCARBONS

DATA PACKAGE

ES-ENGINEERING SCIENCE, INC.

600 Bancroft Way
Berkeley,CA 94710

ORGANIC ANALYTICAL REPORT

Work Order NO.: 4432

Parameter: TPH

Matrix: Soil

Unit: mg/Kg

Analytical Method: 418.1

Date Extracted 10/27/92

QC Batch NO.: S92QCB026TPH

Date Analyzed: 10/29/92

Sample ID:	Client ID:	Result	Reporting Limit	Percent Moisture
4432-01	HI-VW-4'-4.5'	22	5	22.2
4432-02	HI-VW-4.5'-5.0'	15	5	21.8
4432-03	HI-A-3'-4'	ND	4	5.8
4432-04	H2-VW-3'-3.5'	12	4	3.2
4432-05	H2-VW-4'-4.5'	13000	4	6.1
4432-07	HI-BKG-2.5'-3'	84	5	11.4
MSTPH921027	METHOD BLANK	ND	4	NA

TP 11/18

NA_ Not Analyzed
ND_ Not Detected

ANALYST:

GROUP LEADER:

INORGANICS DATA PACKAGE

ES-ENGINEERING-SCIENCE, INC.

600 Bancroft Way
Berkeley, CA 94710

INORGANICS ANALYTICAL REPORT

Client: ES-Denver
Project: AFCEE

TP 11/18/92 TP 11/18/92

Work Order: 4432
Matrix: Solid

Client's ID:	H~~2~~-VW -3'-3.5'	H~~4~~-VW -4'-4.5'	HI-BKG -2.5'-3'
Sample Date:	10/03/92	10/03/92	10/04/92
% Moisture:			
Lab ID:	4432.04	4432.05	4432.06

Parameter	Results			Method	Normal Report Limit	Units	Date Analyzed
Alkalinity	90.	ND	ND	SM 403(M)	50	mg/Kg CaCO3	11/02/92
Moisture	3.2	6.1	9.8	ASTM D2216	.1	% by wt	10/22/92
pH	7.0	6.2	6.6	EPA 9045	NA	pH Units	10/27/92

Note: Samples for alkalinity analysis were extracted using 10mL water for each 1g sample. These water extracts were analyzed for alkalinity, and the results were calculated in the solid on a dry-weight basis.

NA- Not Applicable
ND- Not Detected

ANALYST: Don Gleator

GROUP LEADER:

ES-ENGINEERING-SCIENCE, INC.

600 Bancroft Way
Berkeley, CA 94710

INORGANICS ANALYTICAL REPORT

Client: ES-Denver
Project: AFCEE

Work Order: 4432
Matrix: Solid

Client's ID:	HI-VW -4'-4.5'	HI-VW -4.5'-5.0'	HI-A -3'-4'				
Sample Date:	10/02/92	10/02/92	10/02/92				
% Moisture:							
Lab ID:	4432.01	4432.02	4432.03				
Parameter	----------Results----------			Method	Normal Report Limit	Units	Date Analyzed
Alkalinity	ND	ND	ND	SM 403(M)	50	mg/Kg CaCO3	11/02/92
Moisture	22.2	21.8	5.8	ASTM D2216	.1	% by wt	10/22/92
pH	5.8	6.0	6.1	EPA 9045	NA	pH Units	10/27/92

Note: Samples for alkalinity analysis were extracted using 10mL water for each 1g sample. These water extracts were analyzed for alkalinity, and the results were calculated in the solid on a dry-weight basis.

NA- Not Applicable
ND- Not Detected

ANALYST: Don Gleaton

GROUP LEADER:

ES-ENGINEERING-SCIENCE, INC.

600 Bancroft Way
Berkeley, CA 94710

INORGANIC QC SUMMARY - MS and MSD

Work Order: 4432

% Moisture: NA

Matrix: Solid

Units: mg/Kg CaCO3 (Alk)
% by wt. (Mois)
pH Units (pH)

Lab ID Spk/Dup:	Alkalinity Blank Spk	Moisture 4438.04	pH 4454.01
QC Batch:	452.42	451.82	453.40

Parameter	Date Analyzed MS/Dup	Unspiked Sample	Results MS/Sample	Results MSD/Dup	RPD	RPD QC Limit	Conc Added MS	Conc Added MSD	Percent Recovered MS	Percent Recovered MSD
Alkalinity	11/02/92	0.00	23000.00	23000.00	0	20	23650.00	23650.00	97	97
Moisture	10/22/92		8.33	7.52	11	20				
pH	10/27/92		5.95	6.08	2	20				

* or N = Outside QC Limit:

QC Limits for % Rec: 75 - 125

ANALYST: Don Sleator Date 11/11/92 REVIEWER: MWB Date 11/17/92

File:M1QCMSWM

ES-ENGINEERING-SCIENCE, INC.

600 Bancroft Way
Berkeley, CA 94710

INORGANICS ANALYTICAL REPORT

Client: ES-Denver
Project: AFCEE

Work Order: 4432
Matrix: Solid

Client's ID: Prep Blank

Sample Date:
% Moisture:
Lab ID: Prep Blank

Parameter	Results	Method	Normal Report Limit	Units	Date Analyzed
Alkalinity	ND	SM 403(M)	50	mg/Kg CaCO3	11/02/92
Moisture	NA	ASTM D2216	.1	% by wt	10/22/92
pH	NA	EPA 9045	NA	pH Units	10/27/92

Note: Samples for alkalinity analysis were extracted using 10mL water for each 1g sample. These water extracts were analyzed for alkalinity, and the results were calculated in the solid on a dry-weight basis.

NA- Not Applicable
ND- Not Detected

ANALYST: Don Gleston

GROUP LEADER:

ES-ENGINEERING-SCIENCE, INC.

600 Bancroft Way
Berkeley, CA 94710

INORGANICS QC SUMMARY - LAB CONTROL SAMPLE

Work Order: 4432

% Moisture: NA

Lab ID of LCS:
Alkalinity: 452.42 LCS

Matrix: Solid

Units: mg/Kg CaCO3

Parameter	Date Analyzed LCS	LCS Result	Conc Added	% Rec LCS	Advisory Limits -- % Rec -- Low	High
Alkalinity	11/02/92	23000.00	23650.00	97	80	120

ANALYST: Don Gleaton Date 11/11/92 REVIEWER: [illegible] Date 11/17/92

File:M1QCLCSW

METALS DATA PACKAGE

CASE NARRATIVE
WORK ORDER NO. 4432
METALS

The serial dilution sample result for iron did not agree with the undiluted result within 10%, and the diluted sample result was greater than ten times the iron MDL. All iron results in this batch are therefore flagged with "E".

Client ID's were abridged by the laboratory to facilitate computer entry of analytical data. The following should be used as a reference:

CLIENT ID	ABRIDGED ID
H1-VW-4'-4.5'	H1VW-4
H1-VW-4.5'-5.0'	VW-4.5
H1-A-3'-4'	A-3-4
H2-VW-3'-3.5'	VW-3
H2-VW-4'-4.5'	H2VW-4
H1-BKG-2.5'-3'	BKG2.5

Engineering Science - Berkeley Laboratory
Inorganics Report

INORGANIC ANALYSES DATA SHEET

CLIENT SAMPLE ID: H1VW-4

Lab Name: E_S__BERKELEY_LABORATORY_ Contract: AFCEE_ES-D

Lab Code: ESBL__ Case No.: 4432S SAS No.: _____ SDG No.: A-3-4_

Matrix (soil/water): SOIL_ Lab Sample ID: 4432.01___

Level (low/med): LOW__ Date Sampled : 10/02/92

% Solids: _77.8

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7439-89-6	Iron	7980		E	P

Comments:

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Inorganics Report

INORGANIC ANALYSES DATA SHEET

CLIENT SAMPLE ID

VW-4.5

Lab Name: E_S__BERKELEY_LABORATORY_ Contract: AFCEE_ES-D

Lab Code: ESBL__ Case No.: 4432S SAS No.: _____ SDG No.: A-3-4_

Matrix (soil/water): SOIL_ Lab Sample ID: 4432.02___

Level (low/med): LOW__ Date Sampled : 10/02/92

% Solids: _78.2

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7439-89-6	Iron	6260		E	P

Comments:

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Inorganics Report

INORGANIC ANALYSES DATA SHEET

CLIENT SAMPLE ID

A-3-4

Lab Name: E_S__BERKELEY_LABORATORY_ Contract: AFCEE_ES-D

Lab Code: ESBL__ Case No.: 4432S SAS No.: _____ SDG No.: A-3-4_

Matrix (soil/water): SOIL_ Lab Sample ID: 4432.03___

Level (low/med): LOW__ Date Sampled : 10/02/92

% Solids: _94.2

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7439-89-6	Iron	8630		E	P

Comments:

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Inorganics Report

INORGANIC ANALYSES DATA SHEET

CLIENT SAMPLE ID

VW-3

Lab Name: E_S__BERKELEY_LABORATORY_ Contract: AFCEE_ES-D

Lab Code: ESBL__ Case No.: 4432S SAS No.: _____ SDG No.: A-3-4_

Matrix (soil/water): SOIL_ Lab Sample ID: 4432.04___

Level (low/med): LOW__ Date Sampled : 10/03/92

Solids: _96.8

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7439-89-6	Iron	8160		E	P

Comments:

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Inorganics Report

INORGANIC ANALYSES DATA SHEET

CLIENT SAMPLE ID: H2VW-4

Lab Name: E_S__BERKELEY_LABORATORY_ Contract: AFCEE_ES-D

Lab Code: ESBL__ Case No.: 4432S SAS No.: _____ SDG No.: A-3-4_

Matrix (soil/water): SOIL_ Lab Sample ID: 4432.05___

Level (low/med): LOW__ Date Sampled : 10/03/92

% Solids: _93.9

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7439-89-6	Iron	5460		E	P

Comments:

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Inorganics Report

INORGANIC ANALYSES DATA SHEET

CLIENT SAMPLE ID: BKG2.5

Lab Name: E_S__BERKELEY_LABORATORY_ Contract: AFCEE_ES-D

Lab Code: ESBL__ Case No.: 4432S SAS No.: _____ SDG No.: A-3-4_

Matrix (soil/water): SOIL_ Lab Sample ID: 4432.06___

Level (low/med): LOW__ Date Sampled : 10/04/92

% Solids: _90.2

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7439-89-6	Iron	11600		E	P

Comments:

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Inorganics Report

INORGANIC ANALYSES DATA SHEET

CLIENT SAMPLE ID

PBLANK

Lab Name: E_S__BERKELEY_LABORATORY_ Contract: AFCEE_ES-D

Lab Code: ESBL__ Case No.: 4432S SAS No.: _____ SDG No.: A-3-4_

Matrix (soil/water): SOIL_ Lab Sample ID: PBK 482.22

Level (low/med): LOW__ Date Sampled : 11/04/92

% Solids: 100.0

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7439-89-6	Iron	4.6	U	E	P

Comments:

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Engineering Science - Berkeley Laboratory
Inorganics Report

LABORATORY CONTROL SAMPLE (BLANK SPIKE)

Lab Name: E_S__BERKELEY_LABORATORY_ Contract: AFCEE_ES-D

Lab Code: ESBL__ Case No.: 4432S SAS No.: _____ SDG No.: A-3-4_

Solid LCS Source: ESBL-LCSS___

Aqueous LCS Source: _____

Analyte	Aqueous (ug/L) True	Found	%R	Solid (mg/kg) True	Found	C	Limits		%R
Iron				100.0	92.1		80.0	120.0	92.1

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Inorganics Report

LABORATORY CONTROL SAMPLE (BLANK SPIKE)

Lab Name: E_S__BERKELEY_LABORATORY_ Contract: AFCEE_ES-D

Lab Code: ESBL__ Case No.: 4432S SAS No.: _____ SDG No.: A-3-4_

Solid LCS Source: ESBL-LCSS___

Aqueous LCS Source: _____

Analyte	Aqueous (ug/L) True	Found	%R	Solid (mg/kg) True	Found	C	Limits		%R
Iron				100.0	93.9		80.0	120.0	93.9

Engineering Science - Berkeley Laboratory
Inorganics Report

BLANK SPIKE DUPLICATE

CLIENT SAMPLE ID

LCSSD

Lab Name: E_S__BERKELEY_LABORATORY_ Contract: AFCEE_ES-D

Lab Code: ESBL__ Case No.: 4432S SAS No.: _____ SDG No.: A-3-4_

Matrix (soil/water): SOIL_ Level (low/med): _LOW__

% Solids for Sample: 100.0 % Solids for Duplicate: 100.0

Concentration Units (ug/L or mg/kg as received): MG/KG

Analyte	Control Limit	Blank Spike (S)	C	Blank Spike Duplicate (D)	C	RPD	Q	M
Iron		92.0990		93.8830		1.9		P

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Inorganic Report

ICP SERIAL DILUTION

EPA SAMPLE NO.

H1VW-4L

Lab Name: E_S__BERKELEY_LABORATORY_ Contract: AFCEE_ES-D

Lab Code: ESBL__ Case No.: 4432S_ SAS No.: _____ SDG No.: A-3-4_

Matrix (soil/water): SOIL_ Level (low/med): LOW__

Concentration Units: ug/L

Analyte	Initial Sample Result (I)	C	Serial Dilution Result (S)	C	% Difference	Q	M
Iron	66454.92		73844.92		11.1	E	P

Engineering Science - Berkeley Laboratory

Method Detection Limits (Annually)

Lab Name: E_S__BERKELEY_LABORATORY_ Contract: AFCEE_ES-D

Lab Code: ESBL__ Case No.: 4432S_ SAS No.: _____ SDG No.: A-3-4_

ICP ID Number: TJA_61_____M Date: 08/31/92

Flame AA ID Number : _____ Matrix: SOIL_

Furnace AA ID Number : _____ (ug/L in 1.00g to 100ml digestate)

Analyte	Wave-length (nm)	Back-ground		MDL (ug/L)	M
Iron	271.44			46.0	P

Comments:

FORM X - IN ILMO2.

Engineering Science - Berkeley Laboratory
Inorganics Report

PREPARATION LOG

Lab Name: E_S__BERKELEY_LABORATORY_ Contract: AFCEE_ES-D

Lab Code: ESBL__ Case No.:_4432S_ SAS No.: _____ SDG No.:A-3-4_

Method: P_

EPA Sample No.	Preparation Date	Weight (gram)	Volume (mL)
A-3-4	11/04/92	1.21	100
BKG2.5	11/04/92	1.23	100
H1VW-4	11/04/92	1.07	100
H2VW-4	11/04/92	1.24	100
LCSS	11/04/92	1.00	100
LCSSD	11/04/92	1.00	100
MPA-9	11/04/92	1.04	100
MPB-9	11/04/92	1.21	100
PBLANK	11/04/92	1.00	100
VMP1-9	11/04/92	1.07	100
VMP2-9	11/04/92	1.13	100
VW-10	11/04/92	1.00	100
VW-3	11/04/92	1.03	100
VW-4.5	11/04/92	1.18	100
VW-7	11/04/92	1.01	100

Engineering Science - Berkeley Laboratory
Inorganics Report

ANALYSIS RUN LOG

Lab Name: E_S__BERKELEY_LABORATORY_ Contract: AFCEE_ES-D

Lab Code: ESBL__ Case No.: 4432S_ SAS No.: _____ SDG No.:A-3-4_

Instrument ID Number: TJA 61 M_ Method: P_

Start Date: 11/09/92 End Date: 11/09/92

EPA Sample No.	D/F	Time	% R	Analytes FE
STD1	1.00	1027		X
STD2	1.00	1031		X
STD3	1.00	1036		X
STD4	1.00	1041		X
ICV	1.00	1045		X
ICB	1.00	1050		X
ICSA	1.00	1054		X
ICSAB	1.00	1059		X
CRI	1.00	1104		
ZZZZZZ	1.00	1108		
PBLANK	1.00	1113		X
LCSS	1.00	1117		X
LCSSD	1.00	1122		X
H1VW-4	1.00	1127		X
H1VW-4L	1.00	1131		X
CCV	1.00	1136		X
CCB	1.00	1141		X
VW-4.5	1.00	1145		X
A-3-4	1.00	1150		X
VW-3	1.00	1154		X
H2VW-4	1.00	1159		X
BKG2.5	1.00	1204		X
VW-7	1.00	1208		X
MPB-9	1.00	1213		X
MPA-9	1.00	1217		X
CCV	1.00	1222		X
CCB	1.00	1227		X
VW-10	1.00	1231		X
VMP2-9	1.00	1236		X
VMP1-9	1.00	1241		X
ICSA	1.00	1245		X
ICSAB	1.00	1250		X

Engineering Science - Berkeley Laboratory
Inorganics Report

ANALYSIS RUN LOG

Lab Name: E_S__BERKELEY_LABORATORY_ Contract: AFCEE_ES-D

Lab Code: ESBL__ Case No.: 4432S_ SAS No.: _____ SDG No.:A-3-4_

Instrument ID Number: TJA 61 M_ Method: P_

Start Date: 11/09/92 End Date: 11/09/92

EPA Sample No.	D/F	Time	% R	Analytes: F E
CRI	1.00	1254		
CCV	1.00	1259		X
CCB	1.00	1304		X

TOTAL PHOSPHORUS

TOTAL KJELDAHL NITROGEN

SOIL CLASSIFICATION

DATA PACKAGE

SEQUOIA ANALYTICAL

680 Chesapeake Drive • Redwood City, CA 94063
(415) 364-9600 • FAX (415) 364-9233

Engineering Science, Inc.	Client Project ID:	W.O. #4432	Sampled:	9/2-4/92
600 Bancroft Way	Sample Descript:	Soil	Received:	Oct 7, 1992
Berkeley, CA 94710	Analysis for:	Percent Solids	Analyzed:	Oct 19, 1992
Attention: Tom Paulson	First Sample #:	210-0637	Reported:	Oct 20, 1992

LABORATORY ANALYSIS FOR: Percent Solids

Sample Number	Sample Description	Detection Limit %	Sample Result %
210-0637	H1-VW-4'-4.5'	10	83
210-0638	H1-VW-4.5'-5.0'	10	84
210-0639	H1-A-3'-4'	10	94
210-0640	H2-VW-3'-3.5'	10	97
210-0641	H2-VW-4'-4.5'	10	92
210-0642	H1-BKG-2.5'-3'	10	92

Analytes reported as N.D. were not present above the stated limit of detection.

SEQUOIA ANALYTICAL

Tod Granicher
Project Manager

THIS REPORT HAS BEEN
APPROVED AND REVIEWED BY

Dawson 11/18/92
ESBL PROJECT MANAGER DATE

SEQUOIA ANALYTICAL

680 Chesapeake Drive • Redwood City, CA 94063
(415) 364-9600 • FAX (415) 364-9233

Engineering Science, Inc.	Client Project ID:	W.O. #4432	Sampled:	9/2-4/92
600 Bancroft Way	Sample Descript:	Soil	Received:	Oct 7, 1992
Berkeley, CA 94710	Analysis for:	Total Phosphorous	Analyzed:	Oct 19, 1992
Attention: Tom Paulson	First Sample #:	210-0637	Reported:	Oct 20, 1992

LABORATORY ANALYSIS FOR: Total Phosphorous

Sample Number	Sample Description	Detection Limit mg/kg	Sample Result mg/kg
210-0637	H1-VW-4'-4.5'	10	370
210-0638	H1-VW-4.5'-5.0'	10	290
210-0639	H1-A-3'-4'	10	300
210-0640	H2-VW-3'-3.5'	10	450
210-0641	H2-VW-4'-4.5'	10	600
210-0642	H1-BKG-2.5'-3'	10	460
-	Method Blank	1.0	N.D.

Analytes reported as N.D. were not present above the stated limit of detection.

SEQUOIA ANALYTICAL

Tod Granicher
Project Manager

Please Note:
Analysis results reported on a dry-weight basis.

SEQUOIA ANALYTICAL

680 Chesapeake Drive • Redwood City, CA 94063
(415) 364-9600 • FAX (415) 364-9233

Engineering Science, Inc.	Client Project ID:	W.O. #4432	Sampled:	9/2-4/92
600 Bancroft Way	Sample Descript:	Soil	Received:	Oct 7, 1992
Berkeley, CA 94710	Analysis for:	Total Kjeldahl Nitrogen	Analyzed:	Oct 15, 1992
Attention: Tom Paulson	First Sample #:	210-0637	Reported:	Oct 20, 1992

LABORATORY ANALYSIS FOR: Total Kjeldahl Nitrogen

Sample Number	Sample Description	Detection Limit mg/kg	Sample Result mg/kg
210-0637	H1-VW-4'-4.5'	20	1,100
210-0638	H1-VW-4.5'-5.0'	20	730
210-0639	H1-A-3'-4'	20	70
210-0640	H2-VW-3'-3.5'	20	66
210-0641	H2-VW-4'-4.5'	20	53
210-0642	H1-BKG-2.5'-3'	20	91
-	Method Blank	0.10	N.D.

Analytes reported as N.D. were not present above the stated limit of detection.

SEQUOIA ANALYTICAL

Tod Granicher
Project Manager

Please Note:
Analysis results reported on a dry-weight basis.

SEQUOIA ANALYTICAL

680 Chesapeake Drive • Redwood City, CA 94063
(415) 364-9600 • FAX (415) 364-9233

Engineering Science, Inc.
600 Bancroft Way
Berkeley, CA 94710
Attention: Tom Paulson

Client Project ID: W.O. #4432

QC Sample Group: 210-0637-42

Reported: Oct 20, 1992

QUALITY CONTROL DATA REPORT

ANALYTE	Total Phosphorous	Total Kjeldahl Nitrogen
Method:	EPA365.3	EPA351.4
Analyst:	K. Follett	G. Kern
Reporting Units:	mg/kg	mg/kg
Date Analyzed:	Oct 19, 1992	Oct 15, 1992
QC Sample #:	210-0642	210-0642
Sample Conc.:	420	84
Spike Conc. Added:	100	4000
Conc. Matrix Spike:	560	4000
Matrix Spike % Recovery:	140	98
Conc. Matrix Spike Dup.:	530	3800
Matrix Spike Duplicate % Recovery:	110	93
Relative % Difference:	5.6	5.1

SEQUOIA ANALYTICAL

Tod Granicher
Project Manager

% Recovery:	$\frac{\text{Conc. of M.S. - Conc. of Sample}}{\text{Spike Conc. Added}}$	x 100
Relative % Difference:	$\frac{\text{Conc. of M.S. - Conc. of M.S.D.}}{\text{(Conc. of M.S. + Conc. of M.S.D.) / 2}}$	x 100

SEQUOIA ANALYTICAL

680 Chesapeake Drive • Redwood City, CA 94063
(415) 364-9600 • FAX (415) 364-9233

Engineering Science, Inc.	Client Project ID:	W.O. #4432	Sampled:	Sep 2, 1992
600 Bancroft Way	Sample Descript:	Soil, H1-VW-4'-4.5'	Received:	Oct 7, 1992
Berkeley, CA 94710	Method of Analysis:	ASTM D422-63	Analyzed:	Oct 13, 1992
Attention: Tom Paulson	Lab Number:	210-0637	Reported:	Oct 20, 1992

PARTICLE SIZE DISTRIBUTION BY SIEVE AND HYDROMETER

SIEVE TEST

(A) TOTAL WEIGHT OF SAMPLE:	218.37g
(B) WEIGHT RETAINED IN NO. 10 SIEVE:	33.38g
(C) % PASSING NO. 10 SIEVE:	84.71

SIEVE TEST FOR WEIGHT RETAINED IN NO. 10 SIEVE

SIEVE SIZE	WEIGHT RETAINED, g	% RETAINED	CUMULATIVE % RETAINED	CUMULATIVE % PASSING
1½ in.	0.0	0.0	0.0	100
3/8 in.	7.00	3.21	3.21	96.79
No. 4	10.54	4.83	8.04	91.96
No. 10	15.84	7.25	15.29	84.71

IDEAL PAN = 0.0
IDEAL TOTAL = (B)

PAN	0.0
TOTAL	33.38

HYDROMETER TEST

ELAPSED TIME (T)	TEMP. °C	HYDROMETER READING (H)	CORRECTED READING (R)	(L)	PARTICLE DIAM. (S)	% SUSPENDED (P)
2	21	20	16	13.7	0.035	21
5	21	17	13	14.2	0.023	17
10	21	15	11	14.5	0.016	15
15	21	15	11	14.5	0.013	15
25	21	13	9	14.8	0.010	12
40	21	12	8	15.0	0.0083	11
60	21	11	7	15.2	0.0068	9.3
90	21	11	7	15.2	0.0055	9.3
120	21	10	6	15.3	0.0048	8.0
1440	21	8	4	15.6	0.0014	5.3

WEIGHT OF SOIL USED IN HYDROMETER TEST (D):	65g
HYGROSCOPIC MOISTURE CORRECTION FACTOR (G):	0.983
SPECIFIC GRAVITY (ASSUMED):	2.65
DISPERSING AGENT CORRECTION FACTOR (E):	3
MENISCUS CORRECTION FACTOR (F):	1
TEMP./SPEC. GRAVITY DEPENDANT CONSTANT (K):	0.01348

FORMULAS:
$R = H - E - F$
$S = K [SQRT (L / T)]$
$P = (R / W) 100$
$W = (J \cdot 100) / C$
$J = D \cdot G$

SEQUOIA ANALYTICAL

Tod Granicher
Project Manager

SEQUOIA ANALYTICAL

680 Chesapeake Drive • Redwood City, CA 94063
(415) 364-9600 • FAX (415) 364-9233

Engineering Science, Inc.	Client Project ID:	W.O. #4432	Sampled:	Sep 2, 1992
600 Bancroft Way	Sample Descript:	Soil, H1-VW-4.5'-5.0'	Received:	Oct 7, 1992
Berkeley, CA 94710	Method of Analysis:	ASTM D422-63	Analyzed:	Oct 13, 1992
Attention: Tom Paulson	Lab Number:	210-0638	Reported:	Oct 20, 1992

PARTICLE SIZE DISTRIBUTION BY SIEVE AND HYDROMETER

SIEVE TEST

(A) TOTAL WEIGHT OF SAMPLE:	255.17g
(B) WEIGHT RETAINED IN NO. 10 SIEVE:	4.75g
(C) % PASSING NO. 10 SIEVE:	98.14

SIEVE TEST FOR WEIGHT RETAINED IN NO. 10 SIEVE

SIEVE SIZE	WEIGHT RETAINED, g	% RETAINED	CUMULATIVE % RETAINED	CUMULATIVE % PASSING
1½ in.	0.0	0.0	0.0	100
3/8 in.	0.0	0.0	0.0	100
No. 4	1.48	0.58	0.58	99.42
No. 10	3.27	1.28	1.86	98.14

IDEAL PAN = 0.0
IDEAL TOTAL = (B)

PAN	0.0
TOTAL	4.75

HYDROMETER TEST

ELAPSED TIME (T)	TEMP. °C	HYDROMETER READING (H)	CORRECTED READING (R)	(L)	PARTICLE DIAM. (S)	% SUSPENDED (P)
2	21	12	8	15.0	0.037	12
5	21	10	6	15.3	0.024	9.2
10	21	9	5	15.5	0.017	7.6
15	21	8	4	15.6	0.014	6.1
25	21	8	4	15.6	0.011	6.1
40	21	8	4	15.6	0.0084	6.1
60	21	7	3	15.8	0.0069	4.6
90	21	7	3	15.8	0.0056	4.6
120	21	7	3	15.8	0.0049	4.6
1440	21	7	3	15.8	0.0014	4.6

WEIGHT OF SOIL USED IN HYDROMETER TEST (D):	65g
HYGROSCOPIC MOISTURE CORRECTION FACTOR (G):	0.983
SPECIFIC GRAVITY (ASSUMED):	2.65
DISPERSING AGENT CORRECTION FACTOR (E):	3
MENISCUS CORRECTION FACTOR (F):	1
TEMP./SPEC. GRAVITY DEPENDANT CONSTANT (K):	0.01348

FORMULAS:
$R = H - E - F$
$S = K [SQRT (L / T)]$
$P = (R / W) 100$
$W = (J \cdot 100) / C$
$J = D \cdot G$

SEQUOIA ANALYTICAL

Tod Granicher
Project Manager

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(415) 364-9600 • FAX (415) 364-9233

Engineering Science, Inc.	Client Project ID:	W.O. #4432	Sampled:	Sep 2, 1992
600 Bancroft Way	Sample Descript:	Soil, H1-A-3'-4'	Received:	Oct 7, 1992
Berkeley, CA 94710	Method of Analysis:	ASTM D422-63	Analyzed:	Oct 13, 1992
Attention: Tom Paulson	Lab Number:	210-0639	Reported:	Oct 20, 1992

PARTICLE SIZE DISTRIBUTION BY SIEVE AND HYDROMETER

SIEVE TEST

(A) TOTAL WEIGHT OF SAMPLE:	256.56g
(B) WEIGHT RETAINED IN NO. 10 SIEVE:	99.81g
(C) % PASSING NO. 10 SIEVE:	61.1

SIEVE TEST FOR WEIGHT RETAINED IN NO. 10 SIEVE

SIEVE SIZE	WEIGHT RETAINED, g	% RETAINED	CUMULATIVE % RETAINED	CUMULATIVE % PASSING
1½ in.	0.0	0.0	0.0	100
3/8 in.	41.21	16.06	16.06	83.94
No. 4	26.13	10.18	26.24	73.76
No. 10	32.47	12.66	38.90	61.10

IDEAL PAN = 0.0
IDEAL TOTAL = (B)

PAN	0.0
TOTAL	99.81

HYDROMETER TEST

ELAPSED TIME (T)	TEMP. °C	HYDROMETER READING (H)	CORRECTED READING (R)	(L)	PARTICLE DIAM. (S)	% SUSPENDED (P)
2	21	14	10	14.7	0.037	9.4
5	21	12	8	15.0	0.023	7.6
10	21	11	7	15.2	0.017	6.6
15	21	10	6	15.3	0.014	5.7
25	21	9	5	15.5	0.011	4.7
40	21	9	5	15.5	0.0084	4.7
60	21	7	3	15.8	0.0069	2.8
90	21	7	3	15.8	0.0056	2.8
120	21	7	3	15.8	0.0049	2.8
1440	21	7	3	15.8	0.0014	2.8

WEIGHT OF SOIL USED IN HYDROMETER TEST (D):	65g
HYGROSCOPIC MOISTURE CORRECTION FACTOR (G):	0.995
SPECIFIC GRAVITY (ASSUMED):	2.65
DISPERSING AGENT CORRECTION FACTOR (E):	3
MENISCUS CORRECTION FACTOR (F):	1
TEMP./SPEC. GRAVITY DEPENDANT CONSTANT (K):	0.01348

FORMULAS:
$R = H - E - F$
$S = K [SQRT (L / T)]$
$P = (R / W) 100$
$W = (J \cdot 100) / C$
$J = D \cdot G$

SEQUOIA ANALYTICAL

Tod Granicher
Project Manager

SEQUOIA ANALYTICAL

680 Chesapeake Drive • Redwood City, CA 94063
(415) 364-9600 • FAX (415) 364-9233

Engineering Science, Inc.	Client Project ID:	W.O. #4432	Sampled:	Sep 4, 1992
600 Bancroft Way	Sample Descript:	Soil, H1-BKG-2.5'-3'	Received:	Oct 7, 1992
Berkeley, CA 94710	Method of Analysis:	ASTM D422-63	Analyzed:	Oct 14, 1992
Attention: Tom Paulson	Lab Number:	210-0642	Reported:	Oct 20, 1992

PARTICLE SIZE DISTRIBUTION BY SIEVE AND HYDROMETER

SIEVE TEST

(A) TOTAL WEIGHT OF SAMPLE:	280.69g
(B) WEIGHT RETAINED IN NO. 10 SIEVE:	39.34g
(C) % PASSING NO. 10 SIEVE:	85.98

SIEVE TEST FOR WEIGHT RETAINED IN NO. 10 SIEVE

SIEVE SIZE	WEIGHT RETAINED, g	% RETAINED	CUMULATIVE % RETAINED	CUMULATIVE % PASSING
1½ in.	0.0	0.0	0.0	100
3/8 in.	24.76	8.82	8.82	91.18
No. 4	7.50	2.67	11.49	88.51
No. 10	7.08	2.52	14.01	85.99
PAN	0.0			
TOTAL	39.34			

IDEAL PAN = 0.0
IDEAL TOTAL = (B)

HYDROMETER TEST

ELAPSED TIME (T)	TEMP. °C	HYDROMETER READING (H)	CORRECTED READING (R)	(L)	PARTICLE DIAM. (S)	% SUSPENDED (P)
2	21	26	22	12.7	0.034	30
5	21	24	20	13.0	0.022	27
10	21	24	20	13.0	0.015	22
15	21	22	18	13.3	0.013	24
25	21	19	15	13.8	0.010	20
40	21	19	15	13.8	0.0079	20
60	21	15	11	14.5	0.0066	15
90	21	15	11	14.5	0.0054	15
120	21	12	8	15.5	0.0048	11
1440	21	9	5	15.5	0.0014	6.7

WEIGHT OF SOIL USED IN HYDROMETER TEST (D):	65g
HYGROSCOPIC MOISTURE CORRECTION FACTOR (G):	0.0984
SPECIFIC GRAVITY (ASSUMED):	2.65
DISPERSING AGENT CORRECTION FACTOR (E):	3
MENISCUS CORRECTION FACTOR (F):	1
TEMP./SPEC. GRAVITY DEPENDANT CONSTANT (K):	0.01348

FORMULAS:

$R = H - E - F$

$S = K [SQRT (L / T)]$

$P = (R / W) 100$

$W = (J \cdot 100) / C$

$J = D \cdot G$

SEQUOIA ANALYTICAL

Tod Granicher
Project Manager

SEQUOIA ANALYTICAL

680 Chesapeake Drive • Redwood City, CA 94063
(415) 364-9600 • FAX (415) 364-9233

Engineering Science, Inc.	Client Project ID:	W.O. #4432	Sampled:	Sep 3, 1992
600 Bancroft Way	Sample Descript:	Soil, H2-VW-3'-3.5'	Received:	Oct 7, 1992
Berkeley, CA 94710	Method of Analysis:	ASTM D422-63	Analyzed:	Oct 13, 1992
Attention: Tom Paulson	Lab Number:	210-0640	Reported:	Oct 20, 1992

PARTICLE SIZE DISTRIBUTION BY SIEVE AND HYDROMETER

SIEVE TEST

(A) TOTAL WEIGHT OF SAMPLE:	203.97g
(B) WEIGHT RETAINED IN NO. 10 SIEVE:	33.37g
(C) % PASSING NO. 10 SIEVE:	88.64

SIEVE TEST FOR WEIGHT RETAINED IN NO. 10 SIEVE

SIEVE SIZE	WEIGHT RETAINED, g	% RETAINED	CUMULATIVE % RETAINED	CUMULATIVE % PASSING
1½ in.	0.0	0.0	0.0	100
3/8 in.	4.04	1.96	1.98	98.02
No. 4	15.81	7.75	9.73	90.27
No. 10	13.52	6.63	16.36	83.64

IDEAL PAN = 0.0
IDEAL TOTAL = (B)

PAN	0.0
TOTAL	33.37

HYDROMETER TEST

ELAPSED TIME (T)	TEMP. °C	HYDROMETER READING (H)	CORRECTED READING (R)	(L)	PARTICLE DIAM. (S)	% SUSPENDED (P)
2	21	9	5	15.5	0.038	6.5
5	21	9	5	15.5	0.024	6.5
10	21	8	4	15.6	0.017	5.2
15	21	7	3	15.8	0.014	3.9
25	21	7	3	15.8	0.011	3.9
40	21	7	3	15.8	0.0085	3.9
60	21	6	2	16.0	0.0070	2.6
90	21	5	1	16.1	0.0057	1.3
120	21	5	1	16.1	0.0049	1.3
1440	21	5	1	16.1	0.0014	1.3

WEIGHT OF SOIL USED IN HYDROMETER TEST (D):	65g
HYGROSCOPIC MOISTURE CORRECTION FACTOR (G):	0.983
SPECIFIC GRAVITY (ASSUMED):	2.65
DISPERSING AGENT CORRECTION FACTOR (E):	3
MENISCUS CORRECTION FACTOR (F):	1
TEMP./SPEC. GRAVITY DEPENDANT CONSTANT (K):	0.01348

FORMULAS:

$R = H - E - F$

$S = K [SQRT (L / T)]$

$P = (R / W) 100$

$W = (J \cdot 100) / C$

$J = D \cdot G$

SEQUOIA ANALYTICAL

Tod Granicher
Project Manager

SEQUOIA ANALYTICAL

680 Chesapeake Drive • Redwood City, CA 94063
(415) 364-9600 • FAX (415) 364-9233

Engineering Science, Inc.	Client Project ID:	W.O. #4432	Sampled:	Sep 3, 1992
600 Bancroft Way	Sample Descript:	Soil, H2-VW-4'-4.5'	Received:	Oct 7, 1992
Berkeley, CA 94710	Method of Analysis:	ASTM D422-63	Analyzed:	Oct 14, 1992
Attention: Tom Paulson	Lab Number:	210-0641	Reported:	Oct 20, 1992

PARTICLE SIZE DISTRIBUTION BY SIEVE AND HYDROMETER

SIEVE TEST

(A) TOTAL WEIGHT OF SAMPLE:	228.60g
(B) WEIGHT RETAINED IN NO. 10 SIEVE:	7.04g
(C) % PASSING NO. 10 SIEVE:	96.92

SIEVE TEST FOR WEIGHT RETAINED IN NO. 10 SIEVE

SIEVE SIZE	WEIGHT RETAINED, g	% RETAINED	CUMULATIVE % RETAINED	CUMULATIVE % PASSING
1½ in.	0.0	0.0	0.0	100
3/8 in.	0.0	0.0	0.0	100
No. 4	2.50g	1.09	1.09	98.91
No. 10	4.54g	1.99	3.08	96.92

IDEAL PAN = 0.0
IDEAL TOTAL = (B)

PAN	0.0
TOTAL	7.04

HYDROMETER TEST

ELAPSED TIME (T)	TEMP. °C	HYDROMETER READING (H)	CORRECTED READING (R)	(L)	PARTICLE DIAM. (S)	% SUSPENDED (P)
2	21	7	3	15.8	0.038	4.5
5	21	7	3	15.8	0.024	4.5
10	21	7	3	15.8	0.017	4.5
15	21	6	2	16.0	0.014	3.0
25	21	5	1	16.1	0.011	1.5
40	21	5	1	16.1	0.0086	1.5
60	21	5	1	16.1	0.0070	1.5
90	21	5	1	16.1	0.0057	1.5
120	21	5	1	16.1	0.0049	1.5
1440	21	5	1	16.1	0.0014	1.5

WEIGHT OF SOIL USED IN HYDROMETER TEST (D):	65g
HYGROSCOPIC MOISTURE CORRECTION FACTOR (G):	0.995
SPECIFIC GRAVITY (ASSUMED):	2.65
DISPERSING AGENT CORRECTION FACTOR (E):	3
MENISCUS CORRECTION FACTOR (F):	1
TEMP./SPEC. GRAVITY DEPENDANT CONSTANT (K):	0.01348

FORMULAS:

$R = H - E - F$

$S = K [SQRT (L / T)]$

$P = (R / W) 100$

$W = (J \cdot 100) / C$

$J = D \cdot G$

SEQUOIA ANALYTICAL

Tod Granicher
Project Manager

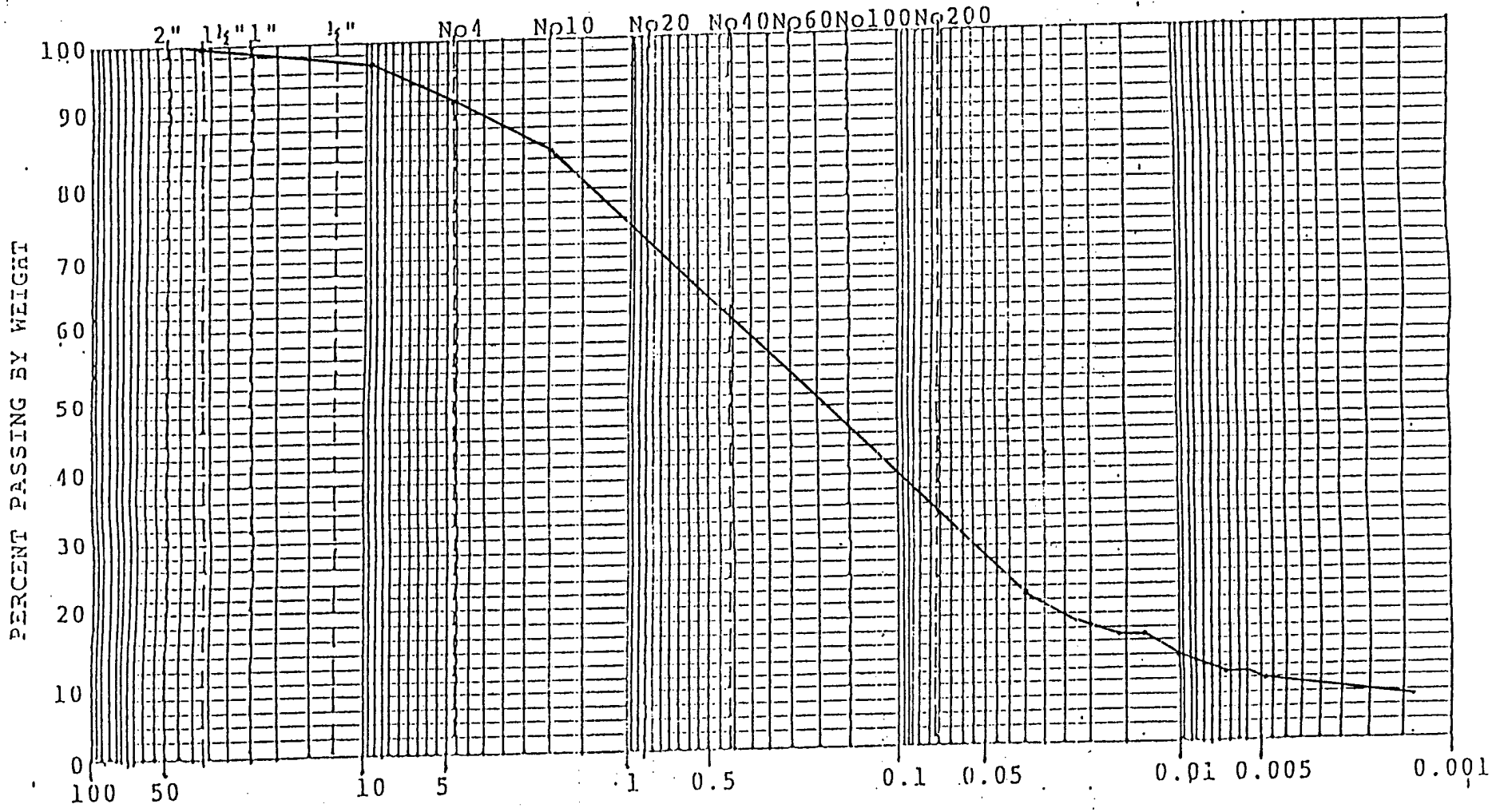
Engineering Science, Inc.

SAMPLE DESCRIPTION: _____

LABORATORY NUMBER: 210-0637

SAND	59%
SILT	27%
CLAY	6%

U.S. STANDARD SIEVE SIZES



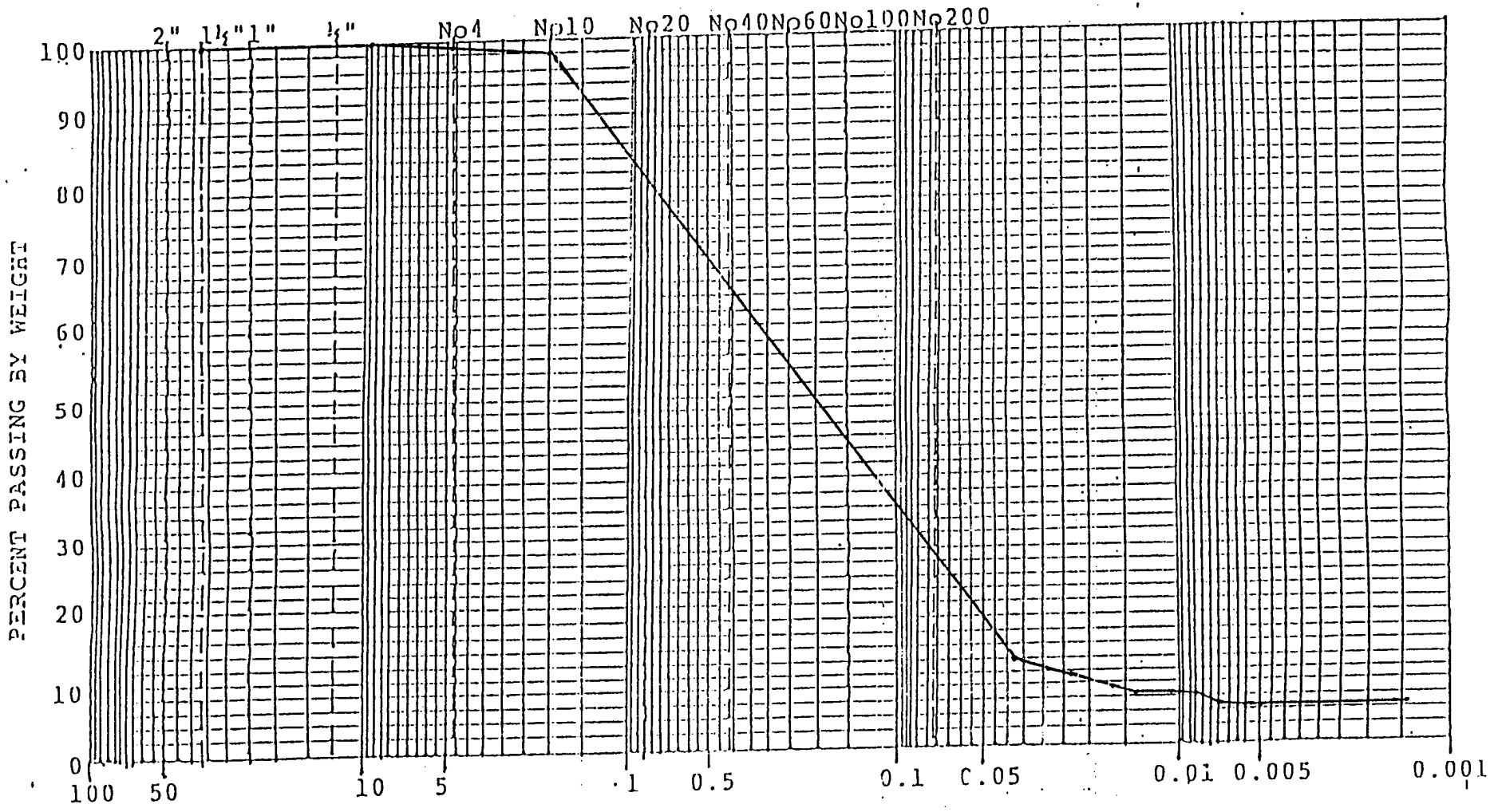
	COARSE	FINE	COARSE	MEDIUM	FINE	SILT SIZES	CLAY SIZES	
OBBLES	GRAVEL		SAND			FINES		

SAMPLE DESCRIPTION: Engineering Science, Inc.

LABORATORY NUMBER: 210-0638

SAND	72%
SILT	23%
CLAY	4.5%

U.S. STANDARD SIEVE SIZES



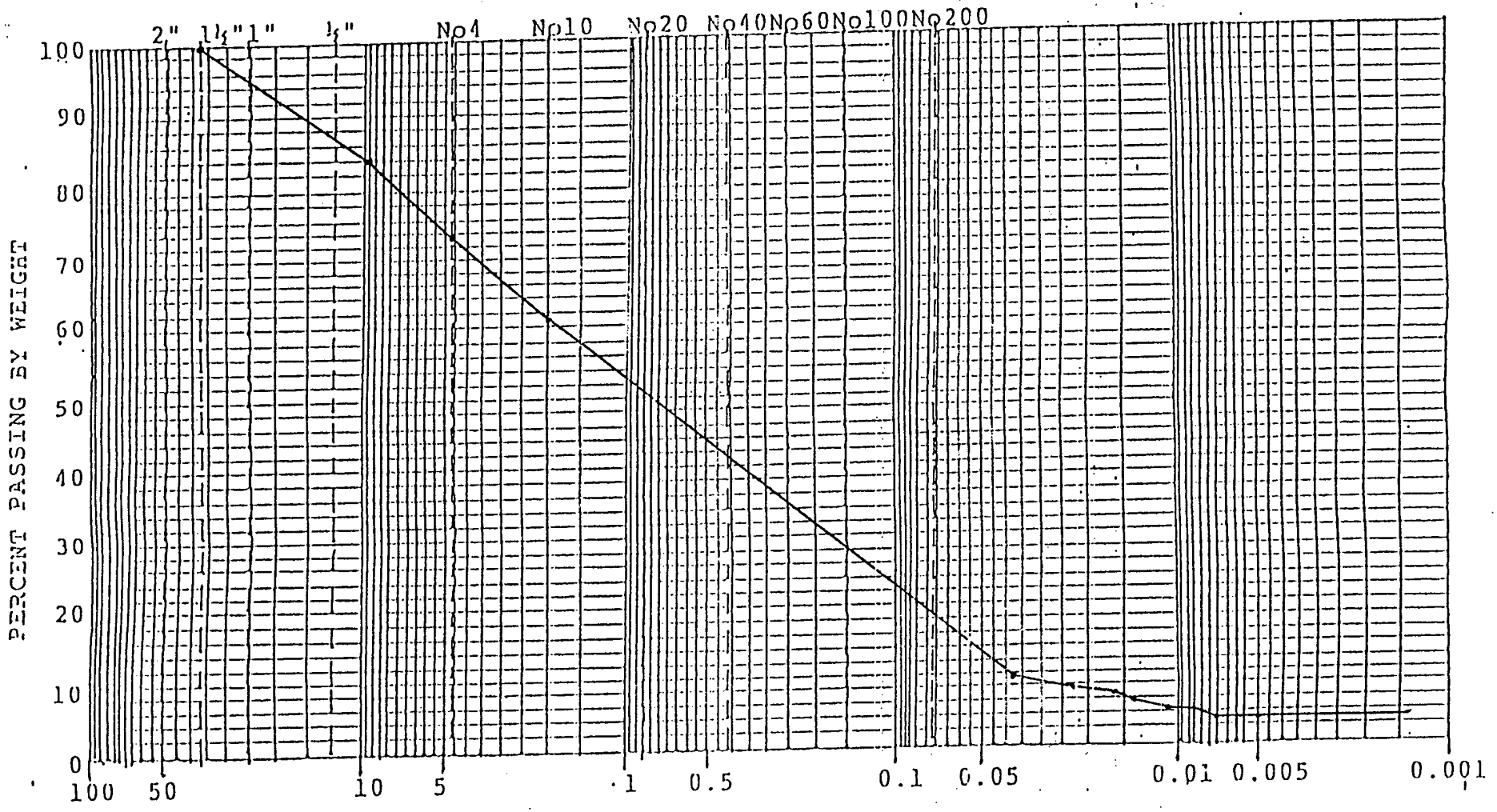
BBLES	COARSE	FINE	COARSE	MEDIUM	FINE	SILT SIZES		CLAY SIZES
	GRAVEL		SAND			FINES		

SAMPLE DESCRIPTION: Engineering Science, Inc.

LABORATORY NUMBER: 210-0639

GRAVEL	26%
SAND	55%
SILT	16%
CLAY	3%

U.S. STANDARD SIEVE SIZES



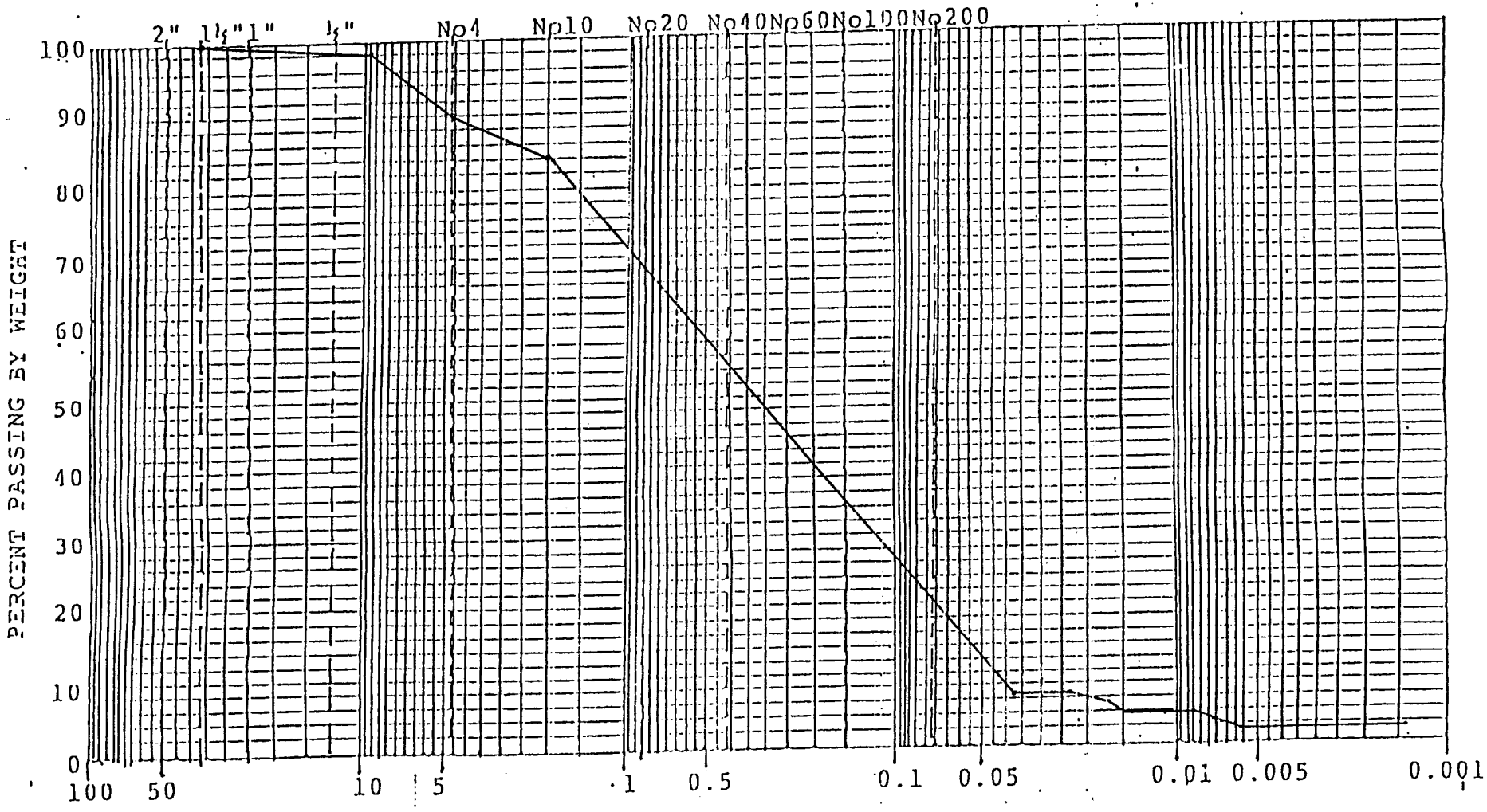
	COARSE	FINE	COARSE	MEDIUM	FINE	SILT SIZES	CLAY SIZES
BBLES	GRAVEL		SAND			FINES	

SAMPLE DESCRIPTION: Engineering Science, Inc.

LABORATORY NUMBER: 210-0640

SAND	69.5%
SILT	19%
CLAY	1.5%

U.S. STANDARD SIEVE SIZES

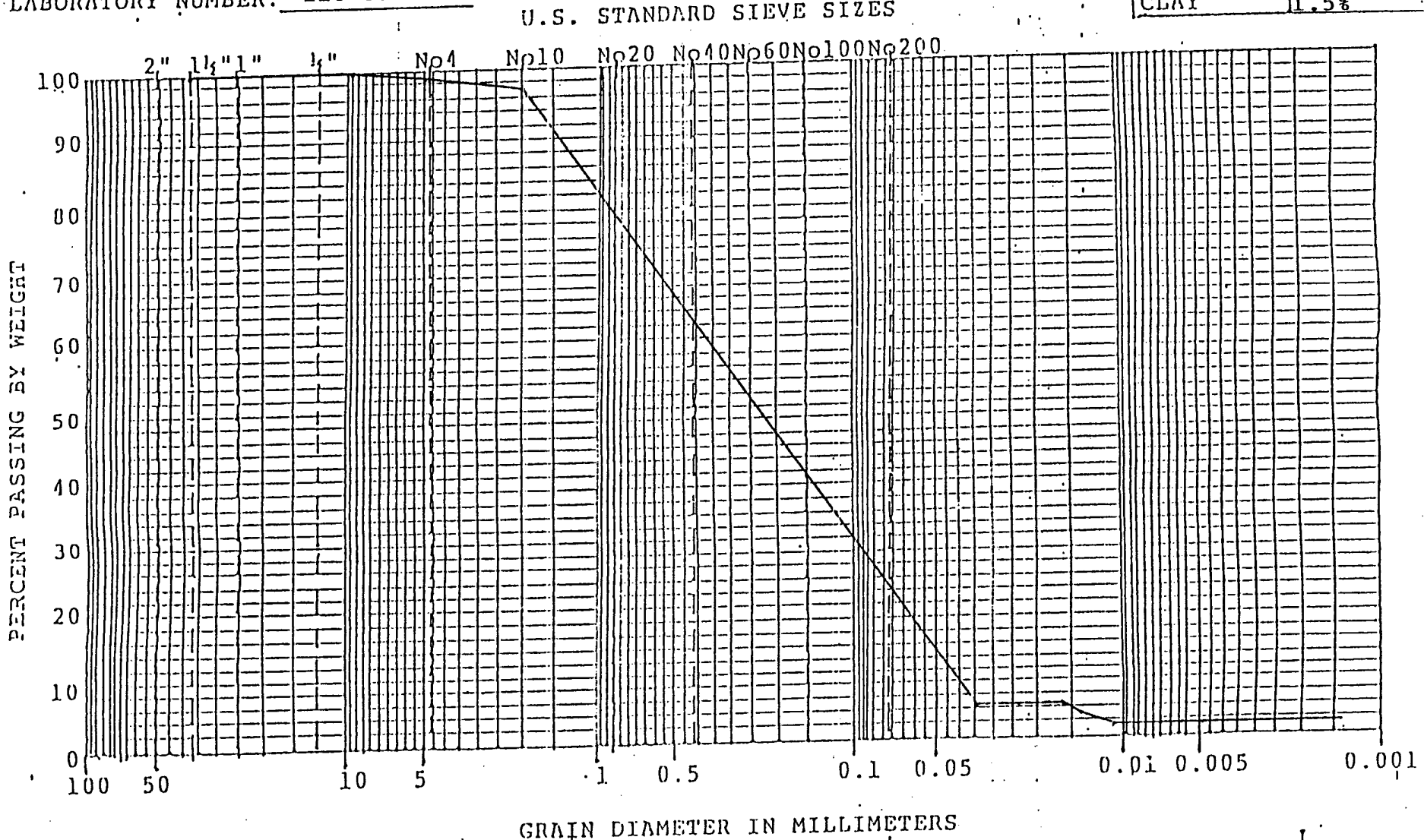


BBLES	COARSE	FINE	COARSE	MEDIUM	FINE	SILT SIZES	CLAY SIZES
	GRAVEL		SAND			FINES	

SAMPLE DESCRIPTION: Engineering Sciece, Inc.

LABORATORY NUMBER: 210-0641

SAND	76%
SILT	21.5%
CLAY	1.5%

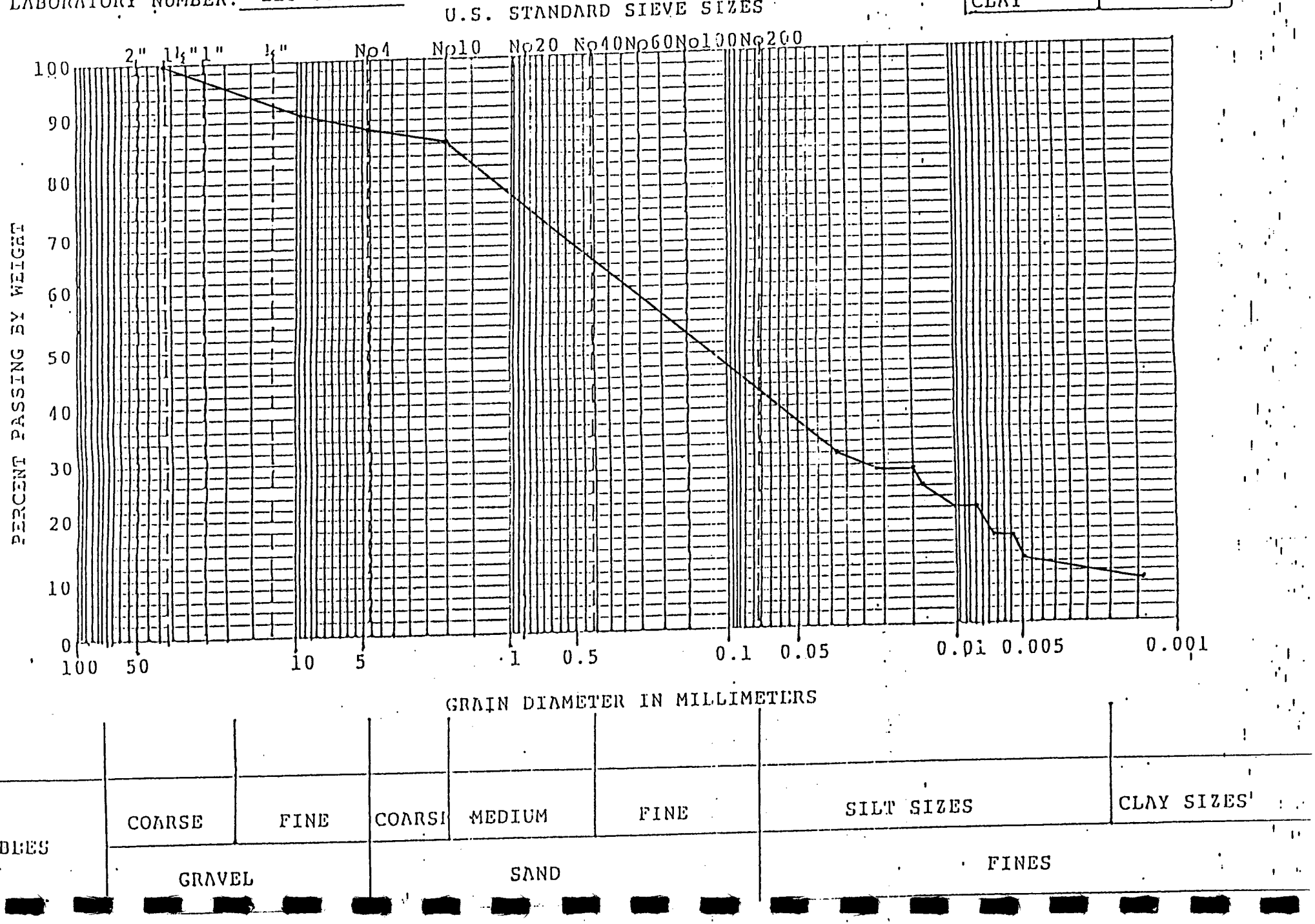


BBLES	COARSE	FINE	COARSE	MEDIUM	FINE	SILT SIZES	CLAY SIZES	
	GRAVEL		SAND			FINES		

SAMPLE DESCRIPTION: Engineering Science, Inc.

LABORATORY NUMBER: 210-0642

SAND	48%
SILT	32%
CLAY	8.5%



ENGINEERING-SCIENCE

CHAIN OF CUSTODY RECORD FOR WATER SAMPLES

ES JOB NO.	PROJECT NAME/LOCATION 4432	PRESERVATIVES REQUIRED												TO: SEQUOIA LAB.
FIELD CONTACT:		ANALYSES REQUIRED												
SAMPLERS NAMES & SIGNATURES		TKN	TKL PHOSPHATE	SIEVE ANALYSIS (DRY CLAYS)										
DATE	TIME	FIELD SAMPLE IDENTIFIER												REMARKS
9/2/92	1500	H1-VW-4'-4.5' (4432.01B)	✓	✓	✓			9210637						REPORT RESULT ON Any SOIL BASIS. USE MDL's FOR REPORTING UNITS. REPORT METHOD BLANKS MS/MSD. (10 day report TAT.) REPORT RESULTS TO: TOM PAULSON, ESB
	1500	H1-VW-4.5'-5.0' (4432.02B)	✓	✓	✓			0638						
	1500	H1-A-3'-4' (4432.03B)	✓	✓	✓			0639						
9/3/92	1200	H2-VW-3'-3.5' (4432.04B)	✓	✓	✓			0640						
	↓	H2-VW-4'-4.5' (4432.05B)	✓	✓	✓			0641						
9/4/92		H1-BKG-2.5-3' (4432.06B)	✓	✓	✓			0642						

FIELD CUSTODY RELINQUISHED BY: [signature] DATE: 10/6/92 TIME: 16:00

SHIPPED VIA: AIRBILL # ON RECEIPT: CUSTODY SEALS? _____; TEMP: _____ °C

RECEIVED FOR LABORATORY BY: [signature] DATE: 10/6/92 TIME: 4:00 pm

JOB No. Engineering-Science JOB No. PE0660.05

Battelle
Columbus Laboratories

CHAIN OF CUSTODY RECORD

Form No. 001

Proj. No. 54468-0640

Project Title: Bioventing HANSCOM AFB

SAMPLERS: (Signature) Doug Heachington / Jim Abbott

DATE	TIME	SAMPLE I.D.	Total Kjeldahl Nitrogen	Total Phosphate	Sieve Analysis	PH	Alkalinity	Iron	Total Soil Moisture	BTEX and TPH	Container No.	Number of Containers	Remarks
02 OCT 92		H1-VW-4'-4.5'				X	X	X	X			1	4oz GLASS
02 OCT 92		H1-VW-4'-4.5'	X	X	X							1	16oz. GLASS
02 OCT 92		H1-VW-4'-4.5'								X		1	BRASS TUBE
02 OCT 92		H1-VW-4.5'-5.0'				X	X	X	X			1	4oz GLASS
02 OCT 92		H1-VW-4.5'-5.0'	X	X	X							1	16oz GLASS
02 OCT 92		H1-VW-4.5'-5.0'								X		1	BRASS TUBE
02 OCT 92		H1-A-3'-4'				X	X	X	X			1	4oz GLASS
02 OCT 92		H1-A-3'-4'	X	X	X							1	16oz GLASS
02 OCT 92		H1-A-3'-4'								X		1	BRASS TUBE
03 OCT 92		H2-VW-3'-3.5'	X	X	X	X	X	X	X			2	4oz glass/16oz GLASS
03 OCT 92		H2-VW-3'-3.5'								X		1	BRASS TUBE
03 OCT 92		H2-VW-4'-4.5'				X	X	X	X			1	4oz GLASS
03 OCT 92		H2-VW-4'-4.5'	X	X	X							1	16oz GLASS
03 OCT 92		H2-VW-4'-4.5'								X		1	BRASS TUBE
04 OCT 92		H1-BKG-2.5'-3'				X	X	X	X			1	4oz. GLASS
04 OCT 92		H1-BKG-2.5'-3'	X	X	X					10/6/92		1	16oz. GLASS
04 OCT 92		~~H1-BKG-3'-3.5'~~ H1-BKG-2.5'-3'						T		X		1	BRASS TUBE

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
Doug Heachington	04 OCT 92 2200				
Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
Relinquished by: (Signature)	Date/Time	Received for Laboratory by: (Signature)	Date/Time	Remarks	
			10/06/92 0930		

Remarks: SEND RESULTS TO: BATTELLE
JEFF KITHEL
505 KING AVE.
COLUMBUS, OH

Page 1 of 1

APPENDIX C

BUILDING 1639 SOIL GAS PERMEABILITY DATA

Table C-1. Results of Soil Gas Permeability Test at Monitoring Point H1-MPA

Time (min)	Pressure ("H_2O) by Depth		Time (min)	Pressure ("H_2O) by Depth	
	2.5′	5.0′		2.5′	5.0′
0	0	0.01	20	0.025	0.32
1	0.05	0.17	23	0.025	0.33
2	0.02	0.21	26	0.025	0.34
3	0.02	0.22	29	0.03	0.35
4	0.03	0.225	32	0.025	0.35
5	0.033	0.235	35	0.03	0.35
6	0.35	0.25	38	0.025	0.35
7	0.03	0.27	41	0.025	0.35
8	0.02	0.28	44	0.02	0.35
9	0.02	0.30	47	0.02	0.35
10	0.015	0.30	50	0.03	0.35
12	0.01	0.30	60	0.02	0.35
14	0.02	0.30	70	0.02	0.36
16	0.02	0.30	80	0.01	0.37
18	0.03	0.32	90	0.02	0.36

Table C-2. Results of Soil Gas Permeability Test at Monitoring Point H1-MPB

Time (min)	Pressure ("H_2O) by Depth		Time (min)	Pressure ("H_2O) by Depth	
	2.5′	5.0′		2.5′	5.0′
1	0.045	0.01	12	0.080	0.015
2	0.06	0.02	50	0.115	0.025
3	0.065	0.01	55	0.115	0.025
4	0.07	0.015	60	0.110	0.02
5	0.075	0.02	70	0.115	0.02
6	0.075	0.02	80	0.113	0.02
7	0.090	0.015	90	0.110	0.022
8	0.092	0.015			
9	0.095	0.02			
10	0.085	0.02			

Table C-3. Results of Soil Gas Permeability Test at Monitoring Point H1-MPC

Time (min)	Pressure ("H_2O) by Depth		Time (min)	Pressure ("H_2O) by Depth	
	3.5′	6.0′		3.5′	6.0′
0	0	0	20	0.01	0.02
1	0	0.01	23	0.02	0.015
2	0.01	0.015	26	0.03	0.035
3	0.01	0.03	29	0.03	0.015
4	0.02	0.02	32	0.02	0.02
5	0.03	0.025	35	0.025	0.015
6	0.02	0.03	38	0.015	0.02
7	0.03	0.01	41	0.025	0.15
8	0.01	0.015	44	0.01	0.01
9	0.015	0.005	47	0.005	0.015
10	0.01	0.02	50	0.02	0.04
12	0	0	60	0.01	0.02
14	0.02	0.01	70	0.01	0.015
16	0.015	0.025	80	0.01	0.01
18	0.03	0.02	60	0.015	0.01

APPENDIX D

BUILDING 1639 IN SITU RESPIRATION TEST DATA

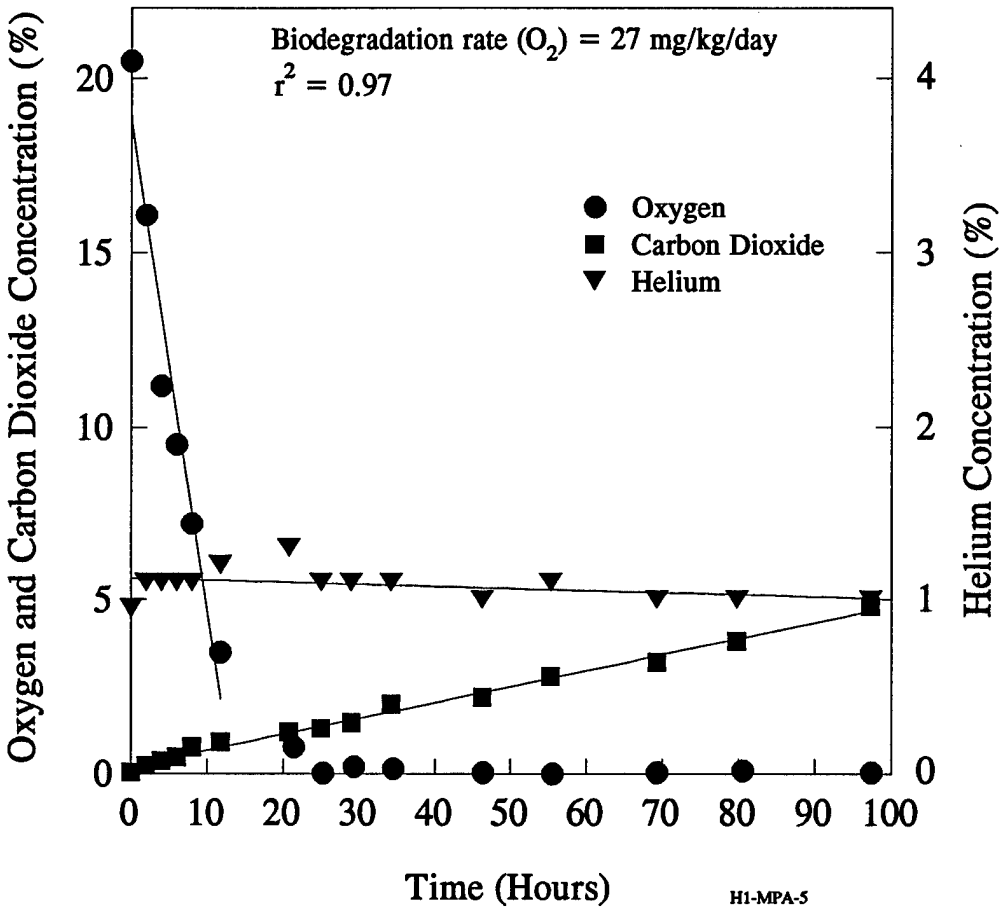


Figure D-1. Oxygen Utilization and Carbon Dioxide Production During the In Situ Respiration Test at Monitoring Point H1-MPA-5.0′

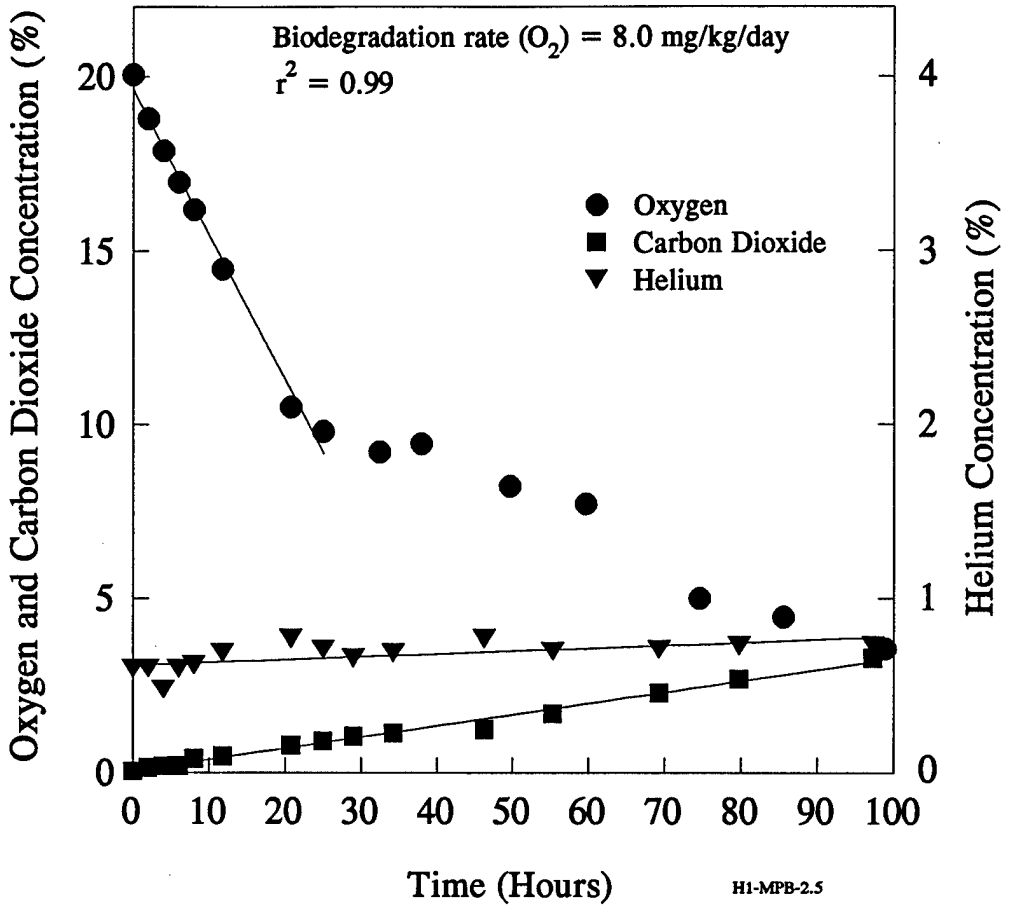


Figure D-2. Oxygen Utilization and Carbon Dioxide Production During the In Situ Respiration Test at Monitoring Point H1-MPB-2.5'

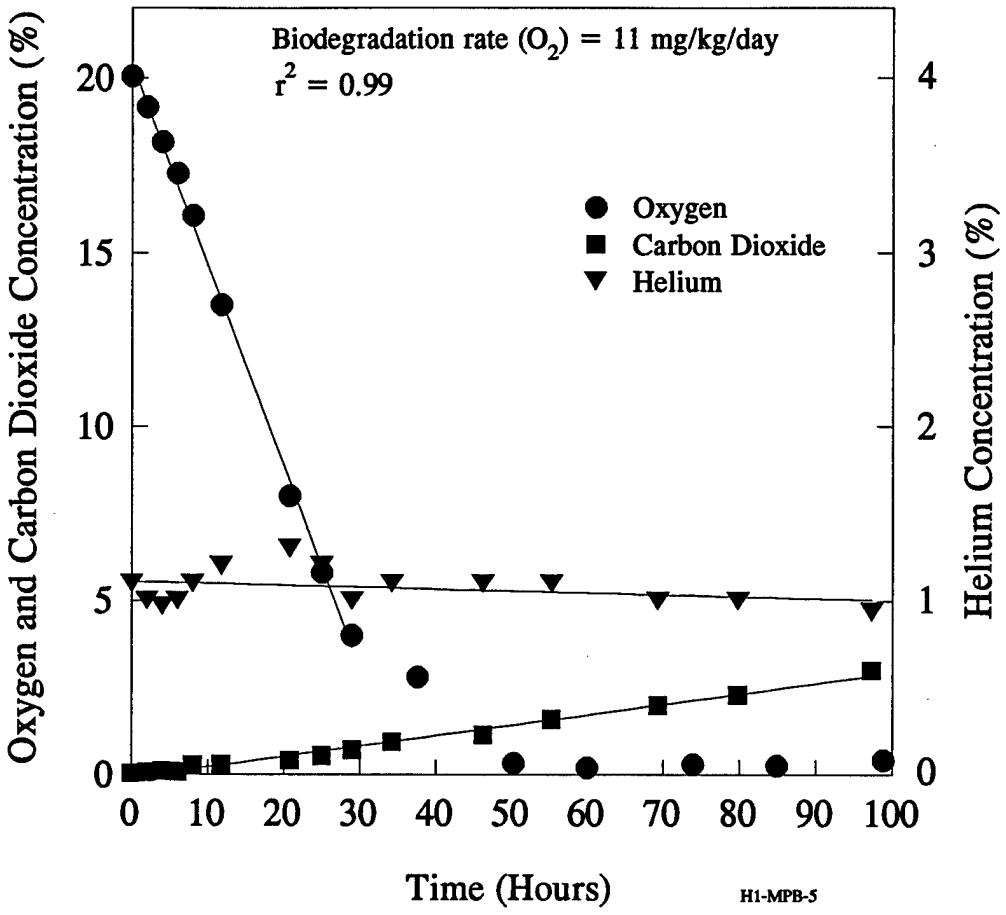


Figure D-3. Oxygen Utilization and Carbon Dioxide Production During the In Situ Respiration Test at Monitoring Point H1-MPB-5.0'

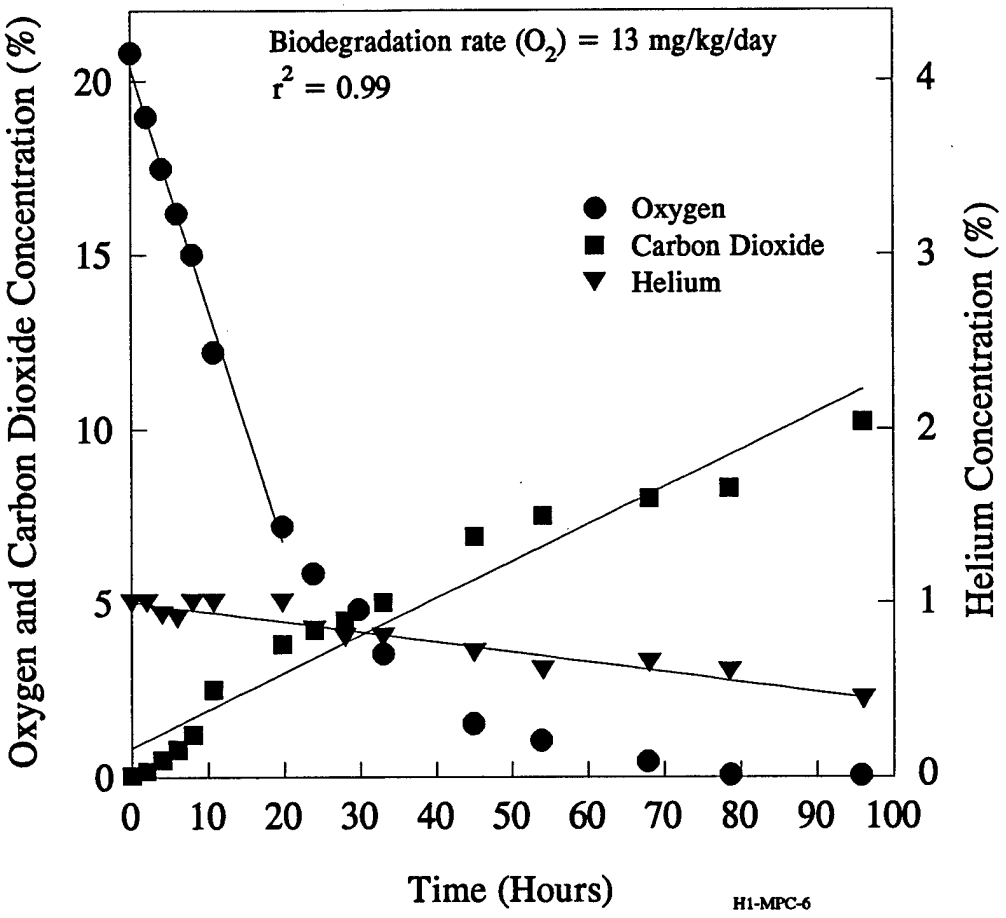


Figure D-4. Oxygen Utilization and Carbon Dioxide Production During the In Situ Respiration Test at Monitoring Point H1-MPC-6.0′

APPENDIX E

BUILDING 1812 SOIL GAS PERMEABILITY DATA

Table E-1. Results of Soil Gas Permeability Test at Monitoring Point H2-MPA

Time (min)	Pressure ("H_2O) by Depth		Time (min)	Pressure ("H_2O) by Depth	
	2.5′	5.0′		2.5′	5.0′
0	0	0	20	0.55	0
2	0.50	0	25	0.55	0
3	0.54	0	30	0.56	0
4	0.55	0.005	35	0.56	0
5	0.55	0	40	0.56	0
6	0.55	0	50	0.57	0
7	0.55	0	60	0.58	0
8	0.55	0	75	0.58	0
9	0.55	0	90	0.59	0
12	0.55	0			
16	0.55	0.55			
18	0.55	0			

Table E-2. Results of Soil Gas Permeability Test at Monitoring Point H2-MPB[1]

Time (min)	Pressure ("H_2O) by Depth		Time (min)	Pressure ("H_2O) by Depth	
	2.5′	5.0′		2.5′	5.0′
0	0	0	14	0.01	0.01
1	0	0	16	0	0.005
2	0	0	18	0.005	0.005
3	0	0.005	20	0	0
4	0	0	25	0	0
5	0	0	30	0.005	0.005
6	0	0	35	0	0
7	0	0	40	0.005	0.005
8	0	0	50	0.005	0.005
9	0	0	60	0.005	0.005
10	0	0	75	0.005	0.005
12	0.005	0.005			

[1] Pressure readings were not collected from monitoring point H1-MPB-7.0′.

Table E-3. Results of Soil Gas Permeability Test at Monitoring Point H2-MPC

Time (min)	Pressure ("H_2O) by Depth			Time (min)	Pressure ("H_2O) by Depth		
	2.5′	4.5′	6.0′		2.5′	4.5′	6.0′
1	0	<0	<0	16	0	<0	<0
2	<0	<0	0	18	0	<0	<0
3	<0	<0	<0	20	0	<0	<0
4	<0	<0	<0	25	0	<0	<0
5	<0	<0	<0	30	0	0	0
6	0	<0	<0	35	0	0	0
7	0	<0	<0	40	0	0	0
8	0	<0	<0	50	0	0	0
9	0	<0	<0	60	0	0	0
10	0	<0	<0	70	0	0	0
12	0	<0	<0	80	0	0	0
14	0	<0	<0	90	0	0	0